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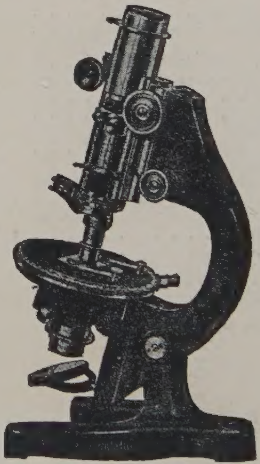

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GEOLOGISKA FÖRENINGENS
I STOCKHOLM
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The Loos-Hamra Region.

By

HARRY VON ECKERMANN.

(Mss. received 27/8 1936.)

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Introduction.

In my paper on the Mansjö Mt., published in 1922 (2) I pointe out in the introduction that the country rocks of the county of Helsingland, in the valleys of the rivers Voxna Älv and Loån, prove to be of a far more complicated character than was indicated by earlie maps and descriptions, and that a revised survey of the geologica maps of the district in question was very greatly needed. I also expressed the hope of being able, at some future time, to contribute t this work by investigations carried out more especially along the uppe valley of the Voxna River.

During the years 1922—1935 I devoted a certain amount of tim each summer to field-work in the region. I originally intended t confine my work to the Loos-district proper, viz. the parish of tha name, but it was gradually extended in so far as I found myself compelled to cross the boundary I first marked out for my labours, i order to find the solution of the problems which successively arose The memoir here presented which has been given the comprehensiv title »The Loos-Hamra Region», embraces, therefore, not only th parish of Loos but also the parish of Hamra (popularly called Ors Finnmark), parts of the parishes of Alfta, Voxna, and Färila withi the government district of Gävleborg, parts of the Ore and Orsa parishe in the district of Kopparberg (Dalecarlia), and, finally, a part of Lillhärdal, in the province of Härjedalen. The total area amounts to abou 1 200 sq. miles (cfr. Pl. CX).

Some of the main petrological features of the country rocks of th northern part of this large district are known from Blomberg's description (1. 1895) of the government district of Gävleborg, which is partl based on Svedmark's very incomplete and fragmentary geologica communications (34) from a surveying journey carried out in th years 1886, 1887, and 1893, mainly along the few roads of the district and also on Svenonius' diary entries respecting a similar visit in 188 Our previous knowledge of the southern part of the area, lying withi Dalecarlia, on which Törnebohm relied for his mapping of the distric for his well-known geological map of Sweden (1910), is limited to th results of short surveying journeys by Törnqvist (1877), Lundboh (1882) and Svedmark (1887).

No detailed scientific examination of the scanty material sample during these years has hitherto been carried out. On examining thi material in the collections of the Swedish Geological Survey, I foun it to be comparatively valueless, partly as a result of the inexactnes of localisations and partly because these, in some cases, were clearl rroneous, a fact which may possibly be connected with the inaccurate aps of the country which were available at the time the journeys ere made. In this memoir, consequently, I have ignored the above entioned earlier material as being unreliable.

Since the publication of Törnebohm's petrological map of Sweden, oostböm communicated in 1916 a brief account of the country rocks f the N.E. part of the parish of Orsa (21), and appended to the decription a sketch map, mainly intended to illustrate the unconformaty hich he had proved to exist between the Dala porphyries and the older oos rocks. As Looström's field work was mostly confined to the W. nd more central parts of the great Dalecarlian porphyry area, however, is sketch is not based on a detailed mapping of the district, so that, ke the map published by Svedmark, it differs essentially from the ap which is now presented in the present memoir.

This was drawn in the field on the scale 1 : 20 000, and the results ave been entered in an original map on the scale 1 : 50 000, which as been presented to the University of Stockholm. On this latter map here are plotted and numbered all the localities from which rock amples have been preserved, the same numbers being found on the orresponding samples, thin slides, and analyses. The collection of amples and thin sections, too, have been made over as a gift to the niversity, where consequently the whole of the primary material will e accessible for comparative study.

During the course of my investigations, the Loos Hamra region proved present possibilities — hitherto unknown in respect of Swedish re-Cambrian rocks — for the drawing up of a complete age sequence, pecially of the younger series. As this must be assumed to be of the tmost importance for the continuance of the great work started by rofessor J. J. Sederholm, the pioneer of Fenno-Scandian pre-Cambrian orrelation, I have endeavoured to give — in addition to a detailed etrographic description of the rocks — also an unusually comprehenve chemical account of them, based on 114 analyses, which will e found in these pages. A list of them and an A—C—F diagram of e eruptive rocks will be found on page 339.

Some of these analyses were carried out during 1922—1926 at a rivate research laboratory I had at that time at Ljusne. A few are e result of collaboration with Prof. J. Petrén, my esteemed teacher by-gone student days, but for the greater number I am indebted the eminent chemists Dr. N. Sahlbom and J. Blix.

The microscopical determinations have all been carried out with a iversal stage — more than 2 000 thin sections having been prepared. he geometric determinations of the actual mineral percentages are all given in weight and have been made with the aid of the Leit integration-stage. The specific weight of the various rocks has bee obtained by weighing in benzol. A few very cross-grained types hav been weighed in water at the University of Upsala, where Pro H. BACKLUND kindly placed the required instruments of the geologica department, and Dr. T. KROKSTRÖM his valuable time, at m disposal.

In the field work I was assisted during the summer of 1923 by D E. NORIN, and in 1924—1925 by G. AHLMAN, M. E. Chief Foreste P. SILFVERSPARRE, who is extremely well acquainted with the grea forest districts around Loos, has for several years assisted me in th search for exposures in these rather inaccessible tracts. To all thes gentlemen I beg to express my hearty thanks.

A special expression of gratitude is due to my most esteemed co league Prof. P. QUENSEL for the interest he has always taken in m labours and for the many good suggestions and fresh view-point which I have gained during our discussions of various problems en countered both in the field and in the laboratory. I am also indebte to the Head of the Swedish Geological Survey, A. GAVELIN, for givin me free access to the dairies and material in the archives and collection of the survey and to my colleague, Dr. N. MAGNUSSON, for many en lightening and valuable discussions on the subject of pre-Cambria chronology, especially in connection with the correlation of the olde Loos series with the results of his own outstanding work in Centra Sweden.

Director A. LAITAKARI of the Finnish Geological Survey, who too some beautiful photographs when he visited me during my work i the field in 1933, has kindly allowed me to reproduce them in th present memoir.

Finally, I have to thank, firstly, the General Director of the Bolide Mining Company, O. FALKMAN, for his permission to examine th prospecting results obtained by the company in the Loos distric and secondly, the chief geological expert, Dr. O. BAECKSTRÖM, who ha most obligingly placed the drill cores and other material at my disposa During the course of 1933 I published the preliminary results of my wor in the records of the Geological Society of Stockholm (G. F. F., and in the same year gave lectures on the subject at Stockholm, He singfors, and Upsala. I am also indebted to my friend, Professor C. TILLEY, who last year offered me the opportunity of placing the essenti points of the pre-Cambrian chronology, as suggested by the Loo Hamra region, before an audience of distinguished British colleagu at the University of Cambridge.

Certain minor differences existing between the points of view then dvanced and those given in the present memoir result from new facts aving been brought to light during the course of my comprehensive evision of the area in the summers of 1934—35 and of new analyses ecessitated by the discoveries. Consequently, I believe the map atached to this work to be essentially correct. However, owing to the carcity of outcrops in large swampy or covered areas of this inaccessible nd sparsely populated region, as well as to the lack in several cases f directly observable contacts between rocks, the possibility of errors s not excluded. New exposures may be uncovered by the road work ow being carried on within the district as relief work for unemployment. But even if a boundary line may have to be shifted a little, or mall remains of one or other rock series may be discovered within reas where they are at present not represented, still, I consider the tratigraphical, tectonical, and petrological outlines of the region so irmly established that possible adjustments may be regarded as negligible, and any delay in publishing the present paper until the compleion of the road work would not be justified.

All the outcrops on which the present mapping of the region is based, re entered in the appended map as small dots.

The Morphology and Tectonics of the Region.

The Loos-Hamra region consists of a rocky highland which, with he exception of small parts of the Voxna River below Lobonäs, lies ntirely above the highest marine limit (M. G.). It is traversed by the water-parting between the river systems of the Ljusne and Dala Rivers nd by three deeply cut valleys, running mainly in a S.E. direction, iz. (1) that of the Voxna River with its tributary from the N., the Loån, elonging to the Ljusnan-system, (2) that of the Oreälv River with ts tributary from the N.N.W., the Sandsjöån, and (3) that of the mån, also a large tributary of the Oreälv, which latter flows into the ala River.

The greatest heights, which attain an elevation of more than 700 m, e within Orsa Finnmark, W. of the Ore and Sandsjö rivers and S. of lvho, where the following conspicuous peaks may be noted: Laxsjönopp (732 m), Korpmäki (732 m), Stora Sandsjöberget (644 m), and ilkalampinoppi (633 m). N.E. of the watershed between the two reat river systems the maximum height around Loos Falls below 600 m, nd in the southeastern part of the area the average height is no more han between 300—400 m above sea-level.

Heavy drift and sand deposits cover most of the country rocks the entire area, and glacio-fluvial sediments are especially thick in th southeastern part of the valleys of the rivers Loån and Voxna äl A continuous esker, especially beautifully developed in the vicinit of the old Voxna Iron-works, can be traced along the Voxna valle N.W. to the inflow of the Loån, where it divides into two ridges, whic with somewhat large or small breaks, run along the two rivers as f as to the northern limit of the map. Another esker follows the valle of Tandsjö Lake and the Sundsjöån brook down to where the latt runs into the river Oreälv and then along this river down towar Dalecarlia.

Along these valleys however, in spite of a heavy covering, the exist as a rule good exposures in the hill sides, most of which rise pe pendicularly, especially along the western side of the valleys. In betwee the valleys there have been found so many outcrops that, as a rule, th establishment of the geological connection of different localities h not involved any great difficulties and has proved unexpectedly reliabl There are some considerable tracts, however, already mentioned, whic are covered by marsh and moorland, where the exposures are few an far between. This is the case N. and N.E. of the Ämådalen statio in the parish of Orsa, and also W. of Loos in the direction of Rullb Both of these areas are typical, easily eroded shale ground, but to judg from the uniform petrological character of the outcrops and the boulder hidden surprises below the surface are hardly probable.

The configuration of the topography displays characteristic vari tions in the different parts of the regions, partly brought about b the difference in erosion of the manifold variety of country rock partly due to tectonic disturbances. E. of the rivers Loån and Voxnaäl where older gneiss granites and migmatites dominate, the hills prese softly undulating lines, as a rule with gently sloping sides. It is onl exceptionally, and then in connection with the dislocation zon described below, that any steep inclines occur (cfr. Pl. I, fig. 1).

The area around Loos is characterized by greenstone hillocks, whic rise conspicuously above the highland, exhibiting protruding terrac of underlying schistose sediments at their base, exposed in the erosio valleys (cfr. Pl. I, fig. 2). Even if sometimes rather steep, they alwa present smoothly rounded outlines, due to the easy weathering of th greenstone. In between them, large, even marshy slopes indicate th sedimentation of younger tuffs, shales, slates and quartzites.

West of the rivers Sandsjöån and Oreälv the landscape is dominate by sharply outlined effusive beds of Dala porphyries projecting o above the other with a slight slope towards the N.W., W., or S.

The perpendicular faces of their eastern fronts are at the base of the different beds, more or less concealed by large naked rock falls and talus, he sharp-edged, comparatively small lumps of porphyry making going very heavy for the exploring geologist.

Here, too, just as around Loos, the respective older and younger edimentation areas around Gråtbäck station and S.E. of Ämådalen tation, each imprint their different but monotonous character on the andscape.

The erosion sculpture within the Loos-Hamra region, however, owes its character less to the distribution of the country rocks, than to he tectonics connected with, and resulting from, the »mise-en-place» of the rocks.

On the whole, the tectonic features are unusually little complicated, esulting from the fact that the district luckily falls just outside the ield of action of the great Caledonian originesis, or has in any case been very little disturbed by that great movement. It seems to constitute an ancient resistance centre, where several successive stages of subsidence and mountain folding have been registered, it is true, but not so strongly as to prevent the history of the development of previous epochs from being read. It is probably this circumstance we have to thank for he preservation of an unusually readily decipherable, chronological eries within Swedish pre-Cambrian.

Before entering upon a description of the tectonic features, I should ike to briefly summarize the distribution and stratigraphy of the country ocks, such as has already been given in my preliminary communication of 1934, and as it will be developed in greater detail in the following pages.

The main portion of the eastern and south-eastern parts of the area s occupied by the oldest archaean rocks, consisting of gray leptitic gneisses, which are frequently highly migmatised, and by old gneiss granites with enclosures of fragments of leptites, the whole intruded by the Mansjö granite. Upon this ancient country of primary rock has been deposited a sedimentation series, the sub-Loosian, which, in the neighbourhood of Loos, has been preserved from erosion by the succeeding super-imposed so-called Loos series, which latter represent a lower division of volcanic and plutonic rock and an upper division of quartitic and slaty sediments. Above the Loos series follows westwards, epresented chiefly N. and S.W. of the Noppikoski Waterfalls (Oreälv River), the extrusion of the Noppi porphyry, overlain in its turn by the edimentary Noppi series and cut by the Rätan granite. Above these eries come the Jotnian Dala porphyries, Rapakivi granites, sandstones and doleritic diabases, which latter conclude the chronological sequence.

Within the oldest eastern migmatitic gneiss area the oldest leptit xenolithes, brecciated and caught in the granite, are, as a rule, steepl tilted, with a uniform N.W.—S.E. strike. The more homogeneous par of the gneiss granite also display a more or less marked schistosity i the same direction. But there are exceptions, however. The eulysit bearing strata at the Mansjö Mt., for instance, form a shallow synclin dipping 20°—30° in a north-western direction, while its continuatio 10 kilometers to the S.E. in the Loberget Hill shows a similar sout eastern dip. The folding axis, consequently, is undulating, but its strik is in conformity with the general strike of the gneiss granite. A quartziti leptite series, occurring further south in the Gäddtjärn Hill, also dip gently to the W., and may be the eastern part of a similar shallow syncline. I shall return later on — in connection with the description o the country rocks — to a probable explanation of these exceptiona occurrences of slight folding, but uniform strike, within the ol archaean.

The eastern district is traversed by two important faults, one running north through the valley of Skrälldalen in a N.W.—S.E. directio towards Räkaklitt Hill, E. of Lobonäs in the south, and the other following the valleys of the rivers Loån and Voxnaälv.

The first-mentioned fault has been studied at Skrälldalen where practically speaking, the whole width of the eroded valley or canyo is a strongly mylonitized gneiss-granite and migmatite, and where th country rock W. of the dislocation has subsided to a lower level tha that on the eastern side. I have been unable to determine the vertica measure of the slip, but the dislocation must have been rather considerable, judging from the higher degree of migmatization and metamorphism at the present erosion level E. of the fault, compared wit the conditions W. of the fault.

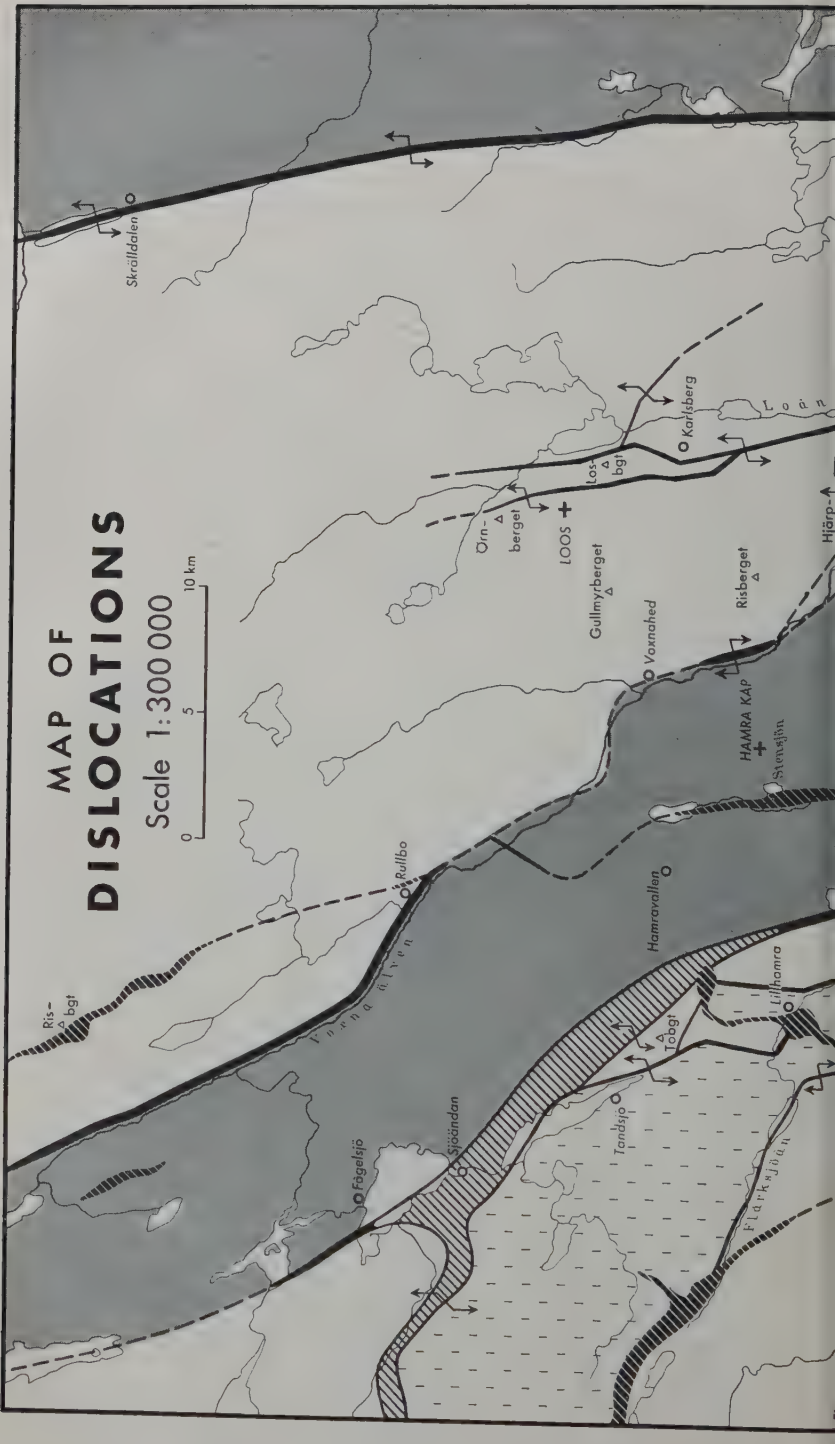
There is an extremely pretty exposure of the southern part of th fault on the western slopes of Räkaklitt Hill, where the gneiss has bee intensely brecciated and criss-crossed by cracks, filled with milk quartz and quartz prisms, between which have crystallized radiall arranged hematite flakes. During the 18th. century these latter wer mined for iron ore to supply an old blast furnace at Voxna. The downthrow at the fault appears here to have been on a smaller scale than i the N., for no clear difference in metamorphism on the two sides of th fault is observable. The easily eroded, and yet still preserved graphite bearing leptites to the S.W. of Räkaklitt at Svensbo previously describe by the author, and their non-occurrence to the E. of the fault, point however, to less depth of erosion, and, consequently, to a sinking o the western rock level.

The development of Lake Ängrasjön and the stream of the same ame in the N., and, in the S., the upper part of the basin of the river ryckån, a tributary of the river Voxna Älv, is no doubt connected ith the Skrälldalen-Räkaklitt fault.

The second dislocation within the old archaean (the great Voxna ault) is beautifully exposed in the Njupaklitt Hill N. of Voxna, where ts perpendicular eastern face is one immense quartz breccia, with large, icely chrystallized, milky quartz prisms, often of considerable size, rowing from the fissure walls towards the centre. In the interstices etween the prisms there occasionally occur small, clear quartz crystals, nd now and then scales of hematite.

The breccia zone is from one to several metres wide, here and there nclosing blocks of the greenstone bordering to the W. This greenstone elongs to the volcanic period of the Loos series. Immediately E. of he fault is found migmatitic gneiss. By studying the breccia, I found, ere too, clear indications that the eastern rock ground has subsided. n one place, for instance, there could be observed a big lump of green- tone caught in the breccia, which had been broken loose and moved ownwards from its very obvious original position in the greenstone all. As, however, it has become jammed against a protruding edge f the western greenstone, it does not afford a basis for any deductions especting the extent of the movement caused by the dislocation. That his must have been fairly considerable, however, is shown by the fact hat, in the breccia, fragments are seen of the actual contact between he greenstone and a gray granitized gneissose leptite, while the present ock opposing the greenstone consists of the eastern limb of the Gädd- ärn leptite-syncline, indicating a comparatively higher level.

Farther N. at the S.W. foot of the Loberget Hill, E. of Lobonäs, one gain traces the dislocation in a great number of breccia boulders, hile the solid rock itself is not exposed. North of Lobonäs the fault rks into two dislocations. Along the road between Lobonäs and Tens- erg, occasional samples of breccia are seen, indicating that one branch f the fault probably mainly follows the Loån stream and is concealed eneath the glacio-fluvial drifts and moraine. Along the eastern cliffs f the Losberget, W. of Lake Losjön, however, the dislocation can once ore be observed in the shape of mylonitized gneiss granite and of a oderate breccia. The greater part of the fault, however, is covered y the talus fall at the foot of the cliffs. The last reliable sign of the rthern extension of the dislocation is found at the eastern foot of he greenstone cliffs of Örnberget, E. of the village of Loos, where there a small outcrop of brecciated sub-Loosian schists immediately below he cliffs. On continuing northwards through the greenstone-porphyry-


MAP OF
DISLOCATIONS
Scale 1:300 000
0
5
10 km
Skrälldalen
Karlsberg
Loån
Los-bgt
Örn-berget
LOOS
Gullmyrberget
Voxnahed
Risberget
Hjärp-
HAMRA KAP
Stensjön
Rullbo
Hamravallen
Ris-bgt
Voxnaälven
Lillhamra
Tobgt
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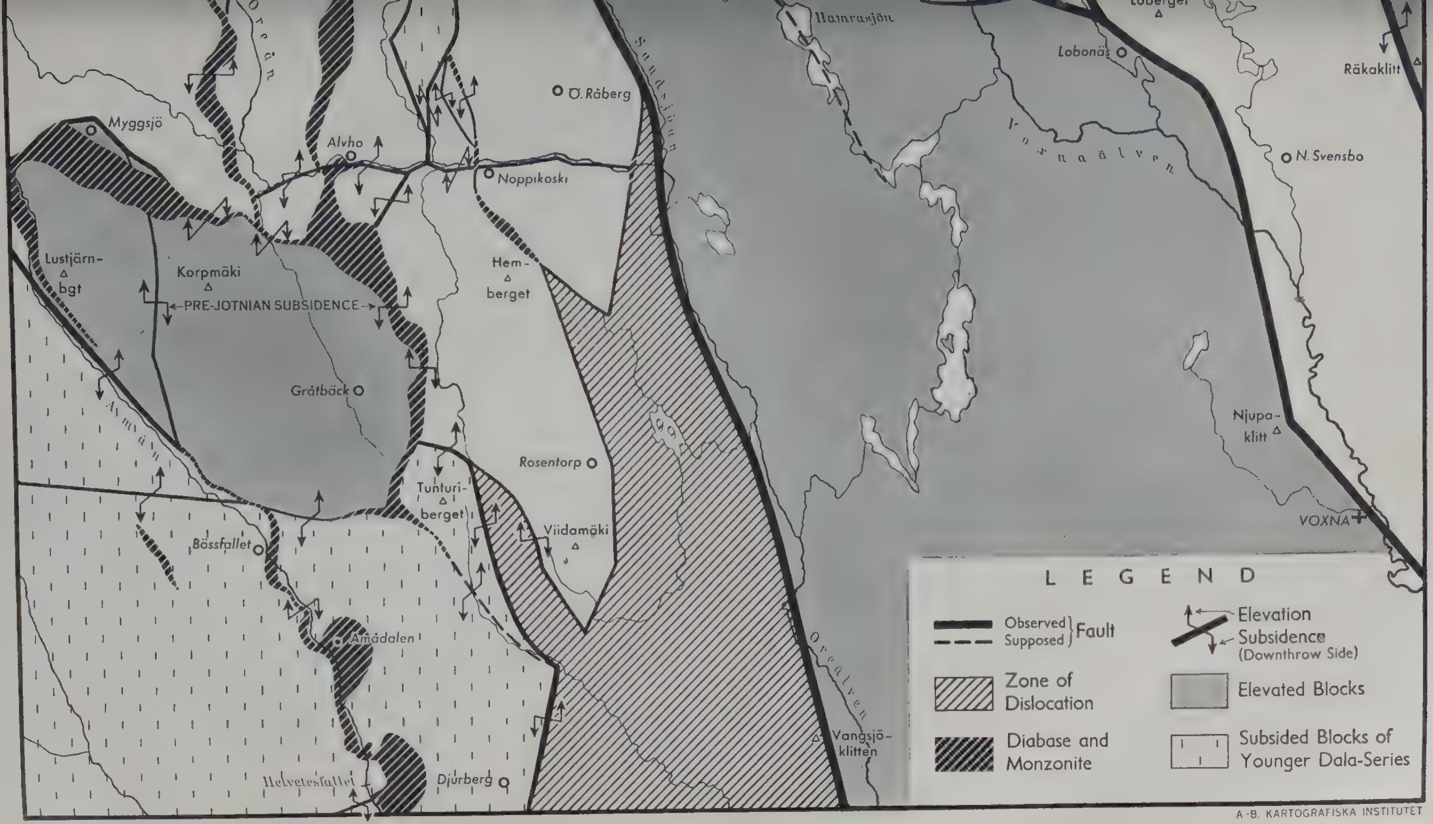

A-B. KARTOGRAFISKA INSTITUTET

Fig. 1. Map of Dislocations.

tuff- and schist-areas no further evidence of the continuation of a fau has been found.

A common feature of the two faults now described is the absen of any horizontal movements of noticeable magnitude along the lin of these dislocations. On the other hand, quite a number of small faults have been observed connected with the dislocation zones, an especially with the western one, where such displacement occurs. have, for instance, previously proved the existence of a small fau running N.E.—S.W. across the Mansjö syncline, whereby the S.W part of the syncline has been displaced somewhat in a S.E. directio unaccompanied by any noticeable vertical slip (cf. 2, fig. 1, Plat XVI).

Immediately W. of Svarttjärn and Storkvarnberget Hill, W. c Lake Lomsjön, there exists a N.S. fault-breccia in the sub-Loosia quartzite and the greenstone, accompanied by some vertical movemen Whereas the two quartzite peaks of the Storkvarnberget Hill ar separated by a small traversing, brecciating W.E. fault, with som lateral, but hardly noticeable, vertical displacement, the, quartz porphyry and the greenstone at Hjärpberget are parted by a W.E dislocation, another crossing the Hemtjärn Hill north of Kuttermäk Along the eastern foot of the hills at Tensberg, as well as along th tongue of granite S.W. of Karlsberg (S. of Loos), another fault announce its presence by N.—S. crush zones in the granite.

Finally, a large fault joining the major fault at Losberget Hill, a an angle of about 60°, is worth mentioning. To the N. of the dislocatio the Fetingsberg ridge rises conspicuously above the surrounding countr Its southern, partly perpendicular side presents the same strikingl crystallized quartz breccia as at Njupaklitt, although radiating hematite scales and clear quartz prisms are more abundant in this case. Th ridge represents a depressed synclinal fold of sub-Loosian schists withi the surrounding garnet-sillimanite-gneisses and migmatites, protecte from erosion by the encasing »chain mail» of the quartz breccia on i southern face, and by pegmatitic dykes from the adjoining Dåase granite on its northern face. The easier erosion of the surroundin ground of actually lower stratigraphic levels has led to the revers geomorphic sculpture of a »horst», which is actually a subsidence.

The evidence that the vertical slip in this case also must be cons derable is provided by the opposing rocks at the southern foot of th cliffs: basal Sub-Loosian quartzites and granites against much young schists. The breccia itself contains, at the very crest of the cliffs, fra ments of the adjoining quartzites, but right down to the foot the brok lumps of schists are predominant.

The valley of the Looån and that of the succeeding part of the Voxna
lv, consequently, coincide with an important line of weakness in the
ock ground, which may be taken as a decisive factor governing their
ath of erosion.

The upper part of the course of the Voxna was probably also deter-
ined by dislocations, a considerable fault, following the N.E. bank of
e river, from the border of Härjedalen down to the vicinity of Rullbo,
eing traceable as a crushing zone in the granite. Its continuation is,
owever, not evident in the schist area S. of Rullbo, where the erosion
f the river channel seems to be governed merely by the zone of weak-
ess, which has arisen along the contact between strongly folded and
eeply tilted schists and older gneiss granites or intruding younger
ranites. There are some indications, however, of its passing east of
e river, crossing it 2 miles north of Voxna Hed, close to where old
ub-Loosian schists have been thrust above younger quartzites (cf.
elow). Still farther south, through the granite N.E. of Hamra, no traces
f a fault are discernible in the well-exposed outcrops along the river,
here an opportunity was afforded of studying a continuous cross-
ection of the river bed in 1933, when the dam for Storlugnet hydraulic
ower station (about 1 km. north of Voxna Hed), was being constructed.
he river, however, flows in close proximity to the border line between
e younger Risberg granite and the old gneiss granite. For the last
retch of its course, down to its union with the Loån, the Voxna Älv
pproximately follows the intrusion contact between the old archaean
ylen gneiss-granite and the still older leptitic gneiss, and at the Hyl-
römmen rapids the erosion of its path just along this zone of weakness
very much in evidence. N.E. of Hylströmmen, however, the triangular
rea of old sub-Loosian quartzites is certainly preserved by down-
ulting.

A traverse dislocation zone, represented by a double fault S. of
ullbo, may also be worth mentioning. The northern fault displaces
oosian tuffitic schist, while, at a southern fault, the lower strata of
e sub-Loosian schists are thrust above their own superimposed quart-
ites. W. of the Voxna Älv there runs through the basin of lakes
amra and Stensjön a N.N.W. fault, which may possibly be a con-
nuation of that described above, crossing the river S. of Rullbo.
he dislocation is indicated by an exposure of highly brecciated gneiss
ranite N.W. of Hamra, as well as by numerous breccia boulders in
e direction towards Rullbo. Farther S. the jotnian doleritic diabase
. and S. of Lake Stensjön has intruded along the same line of weakness.
have not been able to decide with certainty in which direction the
ertical displacement has moved. As, however, relics of old iron-bearing

leptite series occasionally occur along the Hamra ridge, while none ar found W. of the dislocation, a slight subsidence of the ground rocks E of the fault may possibly have taken place.

Finally, in the western parts of the Loos-Hamra region we encounte the strongly evident dislocation system which extends from Lak Fågelsjön in the N. W., past Tandsjö-Lillhamra, and along the river Sandsjöån and Tallsjöbäcken, down to the river Oreälv. Probabl it follows this latter river southwards, the drainage system havin established itself thanks to the presence of the fault.

The northern outset of this dislocation may be traced even withi the Rätan granite, many miles north of Lake Fågelsjön, by narrow somewhat gneissose zones within this granite, which latter is entirel homogeneous elsewhere. On the neck of land between lakes Fågelsjö and Tandsjön, it is directly observable, for example, at Sjöändan, wher all the gneiss granite is mylonitized and brecciated almost past recogni tion, here and there containing fragments of quartsite. On the easter shore of Lake Tandsjön, by the railroad N. of Tandsjö station, ther are large outcrops of ultra-mylonitic Rätan granite, which farther N are overlain by seemingly undisturbed jotnian tuffitic sediments.

In spite of diligent searching, no signs of dislocation have been foun within the sediments, which does not, however, preclude the possibilit that the fault runs E. or W. of these tuffs. There exists a certain ind cation, however, that the faulting is mainly older than the epoch c sedimentation, i. e. is early jotnian or pre-jotnian. As the mylonitisatio and crushing of the granite is observable within a very wide zon extending up to a thousand metres and more E. of the lake, this exter sive dynamic deformation of the granite could hardly have taken plac without also affecting the superimposed, horizontally stratified sed ments in the narrow short strip immediately adjoining the maximu zone of mylonitisation, which latter, consequently, must for the mos part be of an earlier date.

On the other hand, irrefutable evidence is provided, at the souther end of Lake Tandsjö, of continued movement along the fault in jotnia or post-jotnian time. Red porphyry E. of the valley, belonging to th earliest lava flows of the elder Dala porphyries, now lies on the sam level as the considerably younger porphyritic beds on the other sic of the valley. Veins of pegmatite, cutting through the smaller occurrenc of Loos-rocks S. of the porphyries, are plentiful E. of the river Sandsjöå viz. E. of the fault, but do not occur on its western side. Consequentl the area W. of the dislocation has subsided, and as the porphyry bec in Orsa Finnmark generally lie almost horizontal, with a slight W.—S.V dip of 10°—15°, the re-occurrence of the porphyry beds E. of Tands

rther south may afford assistance in obtaining an approximate
easure of the vertical displacement at the fault. A calculation indi-
tes a subsidence of about 200 metres, which may be taken as a mini-
um for the dislocation at Tandsjö (cf. Pl. LXXXII, Fig. 2).

S. of Lake Tandsjö the fault forks into two dislocations, between
ich lies sunk the small area of Loos rocks to which reference has
eady been made. The eastern fault can be traced along the eastern
undaries of the Rapakivi granite (Sandsjö type), S. of the Loos rocks,
d farther along the Sandsjö River, following in close proximity
the contact between the old gneiss granites and the southerly ex-
nsion of the Rätan granite. It has given rise to an extensive mylo-
tisation, which alternately affects both the two above-mentioned
cks. Reference has already been made to the probability that the
ult follows the course of the river Oreälv farther southwards, although
e poverty of exposures along the river mostly prevents direct obser-
tion. Right down at the southern margin of the map, on the western
ore of Oreälv, the gneiss granite of the Vangsjöklitten Hill is so badly
ushed, however, that it may be taken as a confirmatory indication.

Actually, the rock ground S. of the right-angle bend of the Oreälv
of Noppikoski and W. of the river, almost right up the boundary
the porphyries and the jotnian sediments, is so strongly crushed and
angled that one may speak of a wide zone of dislocation rather than
a well-defined fault. The primary textures of the older gneiss-granites,
well as of the Rätan granite, are in many cases totally obliterated
the dynamic metamorphism, and the mapping has been possible
ly by means of paying close attention to occasional remnants of the
iginal rocks, as well as to comparative microscopical mineral deter-
nations and chemical analyses.

In my preliminary report of 1933 I described part of these rocks as
ing Risberg granite of the lower Loos series, while subsequent closer
vestigations, on which the present map is based, have shown them
be the considerably younger Rätan granite. I may point out in
is connection, however, that the, in many cases, almost undecipherable
ate of the rocks, as well as the scarcity of outcrops, makes the eastern
undary of the Rätan granite, as entered on the map in these parts
of the Noppikoski bend, rather uncertain. It may be taken more as
indication of the probable location of the boundary than as an actual
ntact line. Smaller areas of Risberg-granite too may be present
thin the dislocation-zone.

As is well known, the big circular ring-subsidence of the Silurian
cks of Dalecarlia lies at a distance of about 10 km. south of the pres-
t map. No generally accepted explanation of the origin of this

subsidence has as yet been forthcoming. It is, consequently, of gr interest to note the widening of the dislocation zone southwards towar Dalecarlia.

Returning to the western branch fault at Tandsjön, it is not as shar marked as the eastern one, but constitutes rather a brecciating zo in the rocks, which can be observed in the younger quartzites of t Loos series the whole way from Lillhamra down to the river Ore at Noppikoski. The brecciating occurs on the western side towar the Dala and Noppi porphyries. In his day, SVEDMARK was astonish to find this brecciation on the western slope of the conspicuous San sjöberget ridge, and not on its precipitous eastern side, where he advis future investigators to look for the main breccia. Actually, the easte dislocation has to be looked for many miles to the E., at the riv Sandsjön, the cause of the spectacular eastern escarpment of the qua zites being the steep tilting of the rib between the eastern and weste fault towards the W., on the occasion of the further downthrow of t western porphyry area. The subsidence is confirmed by the felsi material derived from the lower porphyry beds — or maybe even t Noppi porphyry — which is found caught in the breccia at the sa level as that occupied by the immediately adjoining porphyrites a basic jotnian tuffs to the W. of the breccia. As the Sandsjö quartzi exhibit a thickness of at least 200 m., this points to an even great vertical minimum displacement than at Tandsjö.

Farther S. of Noppikoski, where the same quartzite borders the superimposed Noppi series, the zone of brecciation has not follow the contact, but runs within the quartzite itself at a distance of abo 200 m. The brecciation is far less intense but more extensive, whi may indicate a smaller vertical displacement along the fault. No d finite conclusions as to the magnitude of the downthrow, howev can be come to in this locality. Crossing the river Oreälv, the disloc tion zone merges into the wide, crushed zone of the granites, alrea mentioned above.

LOOSTRÖM has earlier interpreted the sediment complex of t Noppi series S. of Älvho station as being contemporaneous with t Loos sediments, assuming a system of rectangular faults to accou for their present tectonic position. In my preliminary report of 19 I questioned the existence of these faults in the field and the necessi for their assumption, since the sediments had been proved to belo to a younger sedimentation epoch. Since then, in 1934 and 1935, have extended my study of this particular part of the field, with t result that I have had to modify my earlier view. A certain amou of faulting and considerable tectonic disturbances have been prov o exist, even if they do not accord with Looström's conclusions. Looström conceived the quartzitic and slaty sediments S. of Älvho s being separated from similar archaean sediments which he claimed e had discovered farther to the W. at Lusbo, by a subsided area of orphyrite, bounded at the E. and W. by vertical N. S. faults. He even uggested that the two sedimentary areas united beneath the porphyrite.

The actual facts are really quite different. Firstly, the porphyrite oes not exist, but there is instead a coarse-grained granite, believed o belong to the Rätan group. On the eroded surface of this granite s deposited unconformably the basal conglomerate of the Dala series, – indicated in my preliminary paper as the top conglomerate of the Ioppi-series — followed by superimposed inter-jotnian sediments and reen porphyrite. The quartzite sediments of Lusbo and Middagsberget re consequently not contemporaneous with the older Noppi quartzites, nd the assumed western fault is non-existent.

Nevertheless, the eastern fault really does exist, but it runs steeply ı a N. W.—S. E. direction between the granite and the Noppi sediıents, indicating a considerable subsidence of the eastern area in relaion to the granite. This subsidence is bounded towards the E. by a onspicuous dislocation, separating the Noppi sediments, including the ld tuffitic sediments, from the Noppi porphyries, which dislocation s clearly marked in nature and on the map by the jotnian doleritic iabase intruded along this ancient zone of weakness.

Actually, the diabase circumflows — almost completely like a ring yke — the roughly circular area of the granite and the sediments. The tectonic displacement accompanying the intrusion of the diabase s not, however, that of a cauldron-subsidence within the diabase magma, ut rather an inverted process, owing to which the surrounding porphyry ock ground to the N. and S. of the area has subsided, or the circular lug of older rock been pushed up to higher levels.

For instance, the small cap of green porphyrite on the top of the otnian sediments of the Lustjärnsberget Hill has no equivalent vithin the map, except at a 300—400 ft. lower level within the hills . of Tandsjö in the N., and at Bössfallet in the S. Even if this may nly be taken as an indication, conclusive evidence is found at Älvho, vhere the river Oreälv has eroded its way along two parallel E.W. iabase dykes, sculpturing most interesting canyons, which have ow been laid dry by the blasting of a new by-pass to carry the floated imber north of the earlier turbulent rapids (cf. Pl. XCIX).

The porphyry flows are here seen steeply tilted at an angle of 60°—70° owards the N., an intermediate stratified layer of felsitic tuffite beween a lower coarse red porphyry and an upper felsic violet porphyry making this readily observable. The southern portions of the porphyr beds, south of the river, have, so to say, been left hanging on the side of the relatively uplifted prejotnian plug.

Satisfactory evidence confirming the surrounding subsidence is als obtained along the river Ämån, the basal jotnian conglomerate to th N.E. of the river opposing jotnian sediments on top of the lower Dal porphyries on the S.W. shore.

Turning farther S., another important dislocation is found branchin off from the above discussed circular faulting in a westerly directio N. of the small brook Granvasslan, crossing the Ämån N. of the Övr Bössfallet Waterfall, skirting the southern limits of the extensive Ägg flovasslan marshland at the foot of the hills, and continuing toward the conspicuous Dyverån valley, not included in the present map.

It may be immediately observed, partly as an extensive crushin and mylonitisation of the red porphyrite at Granvasslan close to th railway watch-box on the railroad line, and also as a strong brecciatio and secondary schistosity of the red porphyrite by the river. The rock N. of this fault reappear S. of the fault at a 58 m. lower level. This i clearly shown by the appended sectional map (Pl. CIX) giving a topo graphical survey of the Ämå river bed, carried out by the author b means of a Paulin barometer.

Several other minor dislocations, running in a W.S.W.—E.N.E direction, have also been observed within the southern parts of th region, of which one crossing the diabase S. of Emådalen station ma be especially mentioned, as it is accompanied by a typical pseudo conglomerate within the diabase. This fault is traceable to the W. a a marked schistosity within the porphyries on the main road to Hamra some 1,000 yards S. of the Ämådalen bridge, and its eastern extensio would roughly correspond to the N.W. boundary of the jotnian sedi ments around Toskanberget Hill. This may suggest a down-faultin of this latter area, but, as the present boundaries are based less on th very few exposures in those parts than on studies of the boulders, th mapping of the boundary may not be quite accurate. An extende survey S. of the present map is urgently needed for the interpretatio of the tectonic position of these jotnian sediments, and the autho hopes to be able to undertake this survey very shortly. Until then, th further discussion of the tectonics along the S.W. margin of the ma must be postponed. The same applies to another fault, supposed t cross the Ämå at the imposing Helvetesfallet Waterfalls.

Summarizing what has been said respecting the dislocation tectonic of the Loos-Hamra region, one may say that they are characterize by a N.W.—N.N.W. parting of the rock-ground into more or les

rrow ribs, which are split up into smaller blocks by crossfaults.
e dislocation system is shown on the appended map, Fig. 1, and is
so elucidated by the sections (Tables CV—CIX).

In addition to the vertically directed dislocations other orogenetic
rces have also been active in the Hamra-Loos region, the traces of
veral folding periods being clearly registered in the different sedi-
entary cycles. If we first of all examine the old archaean of the Loos
ea proper, so little remains of the earliest rocks (the leptites), that no
ductions can be drawn as to their folding prior to the brecciation by
e gneiss granites and the migmatization by palingenetic granites of
e Mangsjö type.

The N.W. orientation of the folding axis of the three remaining
gmental synclines at Mansjö, Loberget, and Gäddtjärn, may be
ite incidental or else connected with the regional N.W. strike imposed
on the old archaean during the migmatitization process, or later.

The following sub-Loosian series are also comparatively small remains
m a sedimentation epoch, which, judging by the thickness of the
posits, must have lasted for a considerable geological period. The
tamorphism of the sediments has largely obliterated primary features,
t the original stratified difference between quartzitic and argillaceous
ers remains, and shows remarkably slight signs of folding. The re-
ining parts now outcropping under the Loos-eruptives give the im-
ession of having originally constituted a large shallow synclinal fold
a N.W. folding axis, originating in a subsiding movement rather than
ing due to any real mountain folding. Starting from the conception
the migmatisation as a regional subsidence of the rock ground to
ver and more high-temperatured palingenetic levels — now generally
cepted by Swedish geologists — one may regard the sub-Loos stage
a partial local slow continuation of the process, proceeding during
time when erosion had been generally carried down to previously
lingenetic depths. This continued subsidence of the earth's crust
y not unnaturally be supposed to occur along the general strike of
migmatisation, as this direction will characterize the possible zones
remaining weakness.

During such a period, the sediments will be gradually deposited in
llow basins, folding to synclines in the presence of a continued sub-
ence of the underlying crust, which movement may be increased by
weight of the accumulating sediments. The basaltic fissure-eruption
the Loos greenstones must, however, have taken place at a time when
subsiding movements in this particular part had stopped, and the
iments were even raised again above sea-level. This is demonstrated
the evidence of a slight erosion of the sub-Loosian sediments before

they were covered by the greenstones, the erosion level of those da having partly laid bare the lower strata of the sedimentary series a having even formed polymikt conglomerates, including boulders of t older gneiss granite. This unconformity actually existing between t greenstone and the schists does not, however, seem to be very pronou ced. An intrusion above sea-level is also indicated by the lack of pill lavas, no such typical structures having been observed, even if a f localities may be doubtful.

The present, more accentuated synclinal arrangement of the su Loos series must, however, be explained by the tectonic disturbanc immediately connected with the intrusion of the volcanics, and one m even assume an anticlinal uplift of the synclinally deposited sedimen preceding the eruption and raising the sediments above sea-lev HOLTEDAHL has recently (12) given prominence to the number cases where a bed has been sharply bent down close to a pluton body, either owing to the dragging effect caused by the general su sidence of the magma, after having been solidly attached to the wal or owing to the cauldron subsidence of the central body while t magma moved upwards between the bed rock and the subsiding bloc

Disregarding local uptilting of the sediments immediately adjoini later faults, and an exceptional area around the Voxna Älv, N. of Vox Hed, the sub-Loosian sediments within the central and southern ar of the greenstone-district dip from all sides towards the greensto at an angle of 60°—70°. At the southern end of the sub-Loosian ar the sediments even show a dip of only 30°—40° towards the N. Co sequently, their present tectonic emplacement cannot very well ha been the result of mountain-chain folding in the usual sense of the wor but their displacement from an originally horizontal or slightly synclin or anticlinal position can only be explained by their having been dragg or pressed down by the greenstone eruption. With the eruptives moved, they would exhibit the picture of a »basin» more than of elongated fold. A cross-section at Kvarnberg (S. of Loos) clea shows the synclinal arrangement of the volcanic and pyroclastic roc and also the greenstone beds to the E. and W. dipping towards ea other. Farther north, at the latitude of Kvarnberg, the western lin of the syncline is disturbed by faulting, but west of Loos the quar porphyries of Gullmyrberget clearly constitute the easterly dippi western limb. The eastern extension of the Karlsberg-cross-secti (cf. Pl. CVII) shows the secondary synclinal folding of the sub-Loosi sediments at Karlsberg and Fetingsberg to be partly the result extensive faulting, to which reference has already been made in t preceding pages.

To the north, however, the picture is different, the sediments as well
the overlying greenstone flow being tilted on edge, and the strike
ing reversed from a N.W. to an E.W. direction. This may be observed
ong the Faxen Hills, N.E. of Loos, right on to the western greenstone
llocks N. of Rullbo. A vertical poisition is also occupied by the schists
ong the river Voxna between Rullbo and Voxna Hed, where the super-
iposed greenstone and quartz porphyry tuffs, as well as the eruptives
emselves, display the same direction of schistosity. This local up-
ting and compression of the rocks must have been caused by forces
ting from the N. and N.W., almost at right angles to the original
nclinal folding of the Loos-district. The intrusion of the Rätan gra-

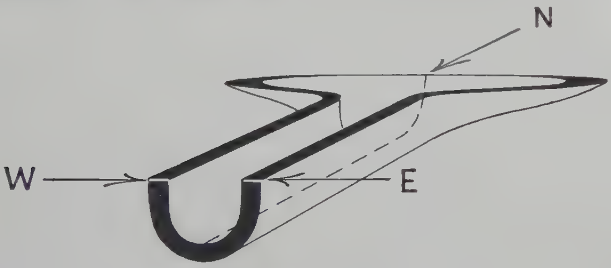

Fig. 2.

te in the N. and of the Risberg granite in the W. and N.W. may easily
count for those tectonic disturbances. The schists along the Voxna
v have, so to say, been pressed together as in a vice between the earlier
sberg granite, intruding from the S. and W., and the later Rätan
anite, intruding from the N. During the latter intrusion, the earlier
idified Risberg granite, and especially its northern parts, have also
en subjected to pressure and become gneissose. This hypothesis fits
very well with the actual emplacement of the sub-Loosian schists,
well as the volcanics and their tuffs, as schematically reconstructed
the appended Fig. 2. It clearly shows that there is no question of an
ption-fissure, crossing the main fissure N. of Loos at right angles,
t of a squeezing-out to both sides of the northern head of the syncline,
ich must lead to the reappearance of the greenstones of the eastern
b of the fold to the east of the original syncline, and of the greenstone
l quartz porphyries of the left limb to the west. An obvious con-
uence of this transversal faulting would be a strongly dynamic
tamorphism of the displaced greenstones, leaving out of account
thermal influence of the proximity of the granite, and the oblite-
ion of primary features — a fact amply verified by my observations
he field. Another deduction to be drawn is the pre-existence of the

Loos-syncline before the intrusion of the Rätan granite, which stricts the downfolding of the syncline to the intrusion period of t greenstone—Risberg-magmas and the accompanying orogenetic movements.

Finally, as regards the quartzites and slaty sediments of the upp Loos-series, which are undoubtedly younger than the Risberg grani but older than the Rätan granite, they have been affected by the mov ments of the second intrusion only, but are nevertheless actually mo folded than the considerably older, lower, tuffitic Loosian and su Loosian sediments. This may be explained by their higher stratigraph levels, where they were not, so to say, kept in place by any overlyin interfoliated or intruded eruptives. Consequently, they were mo easily displaced in different directions and subjected to folding, irrespe tive of their bedding. They also present marked differences betwe the direction of their schistosity and that of their original sedimentatio This may, for instance, be observed in the slate quarries W. of Ryg skog, where the secondary schistosity runs N. 40° W., but the origin sedimentation N. 25° W., or in the Ryggskog quartzite, where t corresponding figures are N. 40 ° W. and N. 10° W. respectively. Th schistosity is conformable with the schistosity imposed on the old series at the bending over of the left limb of the syncline, while there a conspicuous sedimental unconformability between the upper Loo sediments and the lower Loos-series, as well as a smaller one betwe the bottom quartzite of the former sediments and the following slate The same uniform schistosity, but discordant bedding, of tuffit and slates is also found south of Rullbo, where the steep tilting a intensive compression of the sediments, however, makes it less co spicuous.

The small area of Loos-rocks downfaulted S.E. of Tandsjö is mo complicated, being divided into two blocks, the strikes of which cro each other at an angle of about 110°. The sedimentary succession is t same in both, counting from the bottom: acid »hälleflinta»-tuff, narrow layer of black slates, and quartzite. The tuffs are injected a multitude of narrow pegmatitic veins and may belong to the low Loos-series, while the slate and quartzite is free of granite materi and is probably contemporaneous with the upper Loos-sediment No discordant unconformity between the two is measurable, howeve The northern block strikes N. 50° E. and dips 80—90 ° S.E., the southe one strikes N. 60° W. and dips close to the fault, separating the two 90° and farther south 60° S.W. As the strike of the northern blo coincides and lies in line with the corresponding rocks at Rullbo, may reasonably be supposed to represent approximately the origin position of the whole area before the dislocation disturbance took place.

The top quartzites of the upper Loos-series, occurring farther S. from Sandsjöberget ridge down to Noppikoski, present quite another tectonic picture. At Sandsjöberget no traces of any other dynamic influence are found but the brecciating faulting, to which reference has previously been made. Schistosity and bedding coincide perfectly.

East of Noppikoski, where the upper Loos-series reappear in consecutive order from east to west, resting partly on the arkose of the old gneiss-granite, and partly on the sub-Loosian quartzites, differential movements, connected with the extrusion of the Noppiquartz-porphyries to the W., has led to a comparatively strong folding of the phyllitic and slaty middle members of the series, and also to a transversal folding of the bottom quartzites, while the top quartzites immediately beneath the quartz prophyry are only slightly affected. In every case, however, the schistosity and the bedding run parallel to each other, and the series is continuously »younging» towards the igneous contact, as is beautifully demonstrated by the magnificently preserved current beddings (cf. Pl. LI Fig. 1). The whole series represents a twisted E.—W.-fold, the folding-axis running parallel to the river, pitching westwards, and turning at Noppikoski at an angle of about 70° northwards. The E.—W.-syncline is further complicated by an E.—W.-fault following the river (cf. fig. 13).

The evidence of current bedding was extensively used during the evision of the field in 1934 and 1935, in order to check the earlier mapping, and the present author would like to take this opportunity o express his gratitude to Professor E. B. Bailey, who drew his atten-ion to this valuable method during the pre-Cambrian excursion to Scotland in 1934.

The upper Loos sediments must have originated under about the ame conditions as the sub-Loos series. The total absence in both cases f intraformational conglomerates indicates a continuous sedimentation n a slowly subsiding rock-ground, and the frequent occurrence of urrent beddings suggests a shallow sedimentation basin. The uplifting f the series at the close of the transgression can hardly have been very reat, or more conspicuous conglomerates would have been expected n top of the eroded complex. A small unconformable conglomeratic one on top of the upper quartzites beneath the quartz porphyries at Noppikoski, and a somewhat larger one farther to the N., S.E. of Tall-jön, do speak, however, of a distinct folding and erosion of the upper oos-series prior to the extrusion of the Noppi-lavas. So also does the direct contact between the Noppi quartz-porphyries and the Loos phyllites (underlying the Loos top-quartzites) S.E. of Noppikoski.

Very little, however, can be said about the character of this upfolding except that it may be assumed to be closely related to the emplacement of the Noppi-quartz-porphyry and its parent magma, the Rätan granite.

The characteristics of the sub-Loosian and upper Loos epochs apply also to the following sedimentation period of the Noppi series, where conglomerates within the series are conspicuous by their absence. These series occur within the »inverted» cauldron subsidence area, S. of Älvho, — to which reference has already been made, — and on both banks of the small Tallsjöbäcken brook, N.W. of Noppikoski.

While in the former area, the sediments have been subjected to extensive displacements and pitch steeply towards the W., the latter area is very little disturbed by the faulting and is remarkably well preserved. The bedding dips at an easy angle of 20°—40° towards the W., and even primary features of sedimentation, such as ripple marks and sun-cracks, are fully preserved, while in the southern area they are wanting, and as the rocks within the »cauldron uplift» are graywackes only, they may never have existed. While the sediments of the upper Loos series are strongly folded, especially within the Loos area proper, the sediments of the Noppi formation, even where they are steeply tilted, as, for instance, S. of Älvho, do not show anything but a continuous primary sedimentation, running from older strata in the E. to younger ones in the W. Slides, which may have occurred occasionally, have not reversed the sedimentation order between the different layers.

An actual primary folding of the Noppi sediments has nowhere been observed — except perhaps at the S.W. corner of the Älvho area, where graywackes and slates at Lekattkölen form a small secondary syncline, possibly originating in the drag accompanying the fault displacement.

A secondary folding, the folding axis running N.S. parallel to the eastern intrusion front of the great Dala porphyry area, may occasionally be observed.

The Noppi porphyry also displays evident traces of this orogenetic pressure from the W., in the form of a secondary banding, lying at an angle to the direction of the original flow of the porphyry — a feature already observed by SVEDMARK. The feeble tectonising of the contact between the upper Loos sediments and the overlying porphyry at Noppikoski might, perhaps, be explained by the dragging effect caused by this secondary pressure at the contact between two rocks of very different physical character. Analogous fracturing and thrusting on a minor ale are, for instance, described by **Holtedahl** in his previously cited aper. Even if no very complicated folding of the Noppi series can be iown to have taken place they must, nevertheless, have been raised onsiderably higher above the sea-level of those days than the sediients of preceding epochs, as is confirmed by the extensive conglolerates lying unconformably on top of the eroded sediments. This is lso proved by their erosion down to the depths of the plutonic granite 7. of the Älvho area, which granite is directly overlain by the basal onglomerate of the Dala series.

Finally, a few words may be said about the jotnian sediments of iose Dala series, represented mainly to the W. of the Ämå, N.W. of .mådalen and in two large areas at the southern margin of the map. 1 the main, — disregarding vertical block-movements —, these sediients lie »*in situ*» just as they were deposited; often quite horizontally, ometimes with a slight S.E. dip, but for the most part with a slight ip of a maximum of 10°—15° to the S.W. Partly this may be a primary edimentation on a sloping bedrock, partly it may be connected with subsidence of the country rocks towards the well-known dislocation rea around Lake Siljan in Dalecarlia, or towards the central part f the great Dalecarlian porphyry area. In any case, there are no signs hatever of any mountain folding having taken place in jotnian or ost-jotnian time, the post-volcanic tectonics in those days seemingly aving been confined to faultings and slow regional subsidence of the asin areas, where the sediments had been deposited. In this respect iey show a marked similarity to the sedimentation conditions assumed sub-Loosian as well as Loosian and Noppi times.

Consequently, when summarizing the recorded tectonic displaceients of the three great sedimentary epochs of various ages in the oos-Hamra region, following upon the great regional diastrophism f the migmatites, we may say that those tectonics seem to have been ainly governed by local stresses produced by the intrusion and exusion of plutonic and volcanic rocks, and by a comparatively slight ountain folding, intimately connected with the N.W. dislocations id cross-faults accompanying the emplacement of the magma. During ie whole of this long period there hardly occurred any regional folding iginating outside the range of the rocks represented within the region, cept, perhaps, the big uplifts of the area, preceding the Noppi and e jotnian epoch. The regional influence is confined to the slow nking and uplifting of the ground along zones of weakness parallel the N.W. strike of pre-Loosian times, locally overruled, as in the case the E.—W. folding N. of Loos, due to the orogenetic pressure of the ätan granite.

The region undoubtedly constitutes part of a very stable resistanc block, and this may explain the unique preservation of the stratigraph records of such a long history of the development of the pre-Cambria under cover of volcanic flows, while in most other places within Fenn scandia strong regional orogenetic activity broke up the protectin effusives during the accompanying folding, and the subsequent erosio left nothing but fragments which are difficult to interpret. In the Fi I have endeavoured to draw a picture of the tectonics described abov and I would also refer the reader to the special sectional map appende to this memoir.

The Stratigraphy of the Region.

In order to give a comprehensive view of the stratigraphy resultin from my researches within the Loos-Hamra region, I used in my pr liminary report a new type of schematical diagram which speaks fo itself, and which I reproduce in Fig. 3, slightly altered to accord wit the somewhat modified view set out in this memoir.

The left vertical boundary line of the diagram represents the strat graphic sequence occurring within the appended map. The obliqu upper part of the boundary stands for still younger Dala series beyon the southern margin of the map, between Ämådalen and Orsa. Th age-sequency established in connection with the Loos-Hamra regio consequently, covers a longer span of time than that of this memoi Reference has already been made to this extended survey of the Em dalen—Orsa area, which the present author hopes shortly to make th subject of a special paper.

The various plutonic rocks are represented as intersecting their ow effusives, which also include the tuffitic members of their period volcanic activity. In all instances an intersection of the prima pyroclastic rocks has been observed in the field, except in the ca of the Rätan granite. As, however, the Rätan granite is unquestionab the parent magma of the Noppi porphyries, the theoretical possibili of such an intersection may be taken for granted.

A few quantitatively subordinate rocks are omitted from the diagra viz, the albite and andesinite dykes within the Loos-greenstone, th alkaline diabase at Noppikoski, and the quartz-porphyric granophyr dykes within the doloritic diabase at Stensjön.

The divisional nomenclature employed in the diagram is fully di cussed in the concluding chapter of the present memoir (cf. p. 33

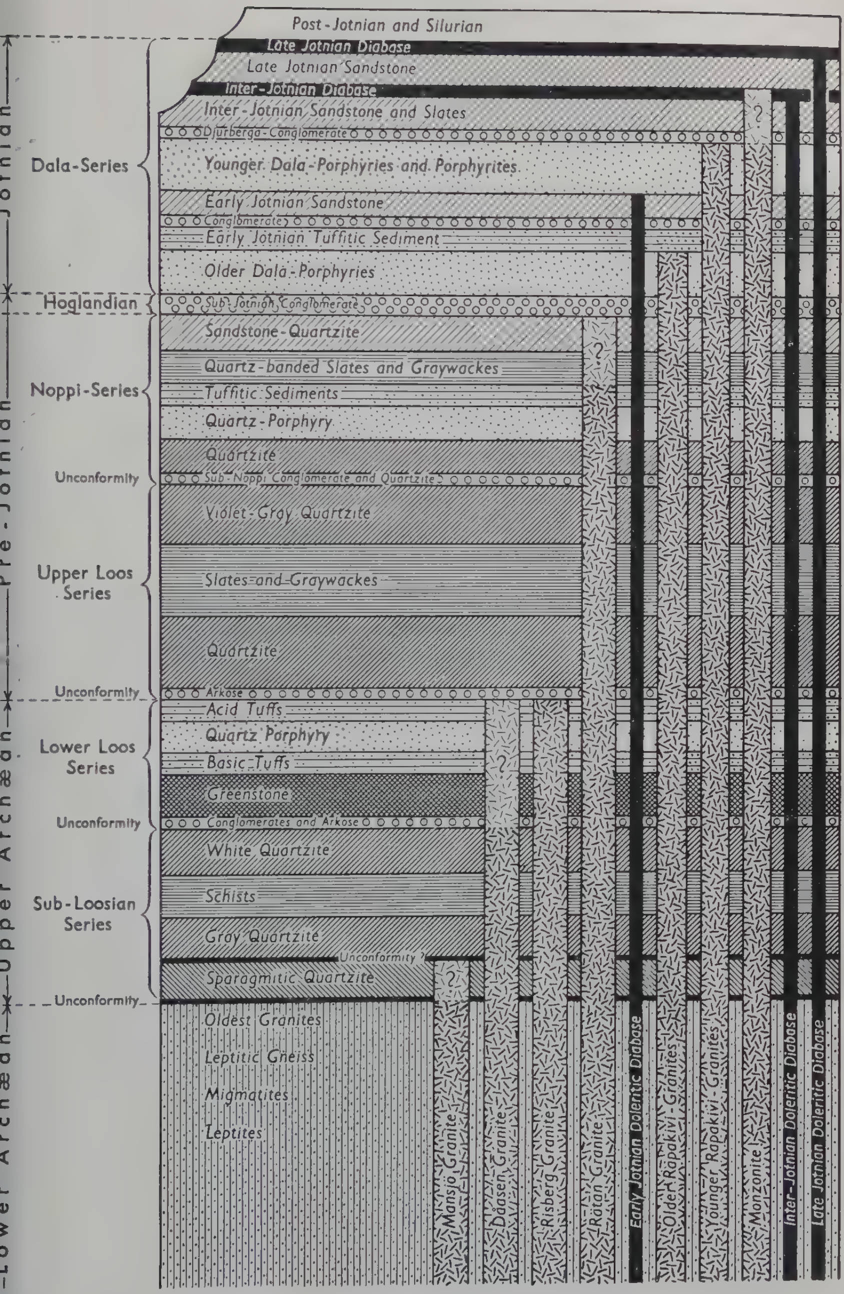

Fig. 3. Chronological Diagram of the rock-sequences within the Loos-Hamra Region.

The Lower Archæan (Sveonian Cycle).

No formation directly comparable with the leptites of Central Sweden is found within the present region, nor does such a formation exist within the whole province of Hälsingland, if the word leptite is taken in its petrographic sense. The word leptite was introduced at the International Congress of 1910 in Sweden as a term for felsitic rocks of recognisable volcanic or pyroclastic primary texture, constituting the oldest known earth crust, brecciated by the earliest granites.

Either the present erosion level within the region is a considerably deeper one than that of Central Sweden, or else the metamorphic stage is much more advanced. In both cases the result should be an almost total obliteration of the primary features of those rocks which, originally, were true leptites even in the textural sense. When using the word leptite, however, the author does not refer to any textural type of rock, but merely wishes to express that the rocks thus termed, whether volcanic or sedimentary, are of the same age as the leptites of Central Sweden, irrespective of texture and volcanic origin. This broadening of the sense of the term, from being the petrological designation of a certain type of rock to one embracing the whole series of different rocks within this formation, is, too, generally accepted by Swedish geologists to-day.

The correlation of the Loos-Hamra-leptitic areas with the unquestionable leptites of Central Sweden is based on the successive grading of the latter rocks into the schists of the present memoir, observable along the profile of the E. coast, previously described by the author (2). The leptite area round Hamrånge, for instance, and its small iron-ore deposits, display such similarities with the true iron-ore-bearing leptites of Torsåker to the S., that their correlation cannot be doubted. Following the leptites towards the N., a striking increase in metamorphism is noted, which gradually advances more and more the deeper one gets into the granitic areas of the province of Hälsingland. The same metamorphic phenomenon is repeated farther westward on passing from the true leptites of S. Dalecarlia to the migmatite areas of Loos.

We find exactly the same evolution which Magnusson has described from Södermanland (23), where he has shown the leptites of Central Sweden (Bergslagen) southwards, to be subjected to an increasing metamorphism grading into the pegmatitized and granitized areas of the so-called Sörmland-gneisses. He has also shown how a careful study of the transformation makes the mapping of the original leptitic areas possible, even when their major parts are diluted to »spectral shadows» of more or less concentrated, but often tectonically and even stratigraphically oriented, leptite-material within the gneiss-granite.

Any »basement» to the leptites of Central Sweden has never been found and may still less be expected to occur within the Loos-Hamra region. In the immense magma-ocean into which the leptitic land-area subsided, granite injections, orogeneses and thermo-metamorphism have so recrystallized the leptites along the contacts that an originally finely-grained leptite has certainly been altered into coarse-grained gneiss. Leptites and granites alike have acquired the same gneissose texture by convergent metamorphism, and this certainly, at considerable distance from the underbedding which, of course, once existed but is now undecipherable, even if it were found exposed.

The leptite areas of the Loos-Hamra region are situated mostly within ts E. districts, where large or small xenolithic fragments occur of still recognisable primary sedimentation. Within other parts of the district, more advanced metamorphism has changed the leptites into biotite-schists grading into garnet-sillimanite-cordierite-andalusite-gneisses. The largest areas, however, are occupied by more or less homogeneous migmatites, sometimes with a dominating percentage of leptitic material, sometimes with a material so diluted that one may be in doubt as to whether the rocks should be considered a migmatitized leptite or a contaminated granite. All these migmatitized and mostly schistose rocks have a characteristic N—NW. strike and a vertical dip. The brecciating and migmatitizing granites are, respectively, the earliest archæan granites (SEDERHOLM's Group No. I) and the Mansjö granite (SEDERHOLM's Group No. II).

The migmatites of the present region have not been subjected to any really detailed study, the main interest of the present survey being concentrated on the younger rocks. The treatment of the old archæan is, consequently, rather cursory, and the map-boundaries between granites and migmatites must only be taken as approximative, ndicating a dominating amount of the one member or the other of the anatexis process, only the larger features of distribution being emphasized. In the field, consequently, small areas of migmatites not shown on the map may be found within the gneiss granites or small areas of granite may occur within the migmatites.

The Leptites of Primary Sedimentation Features.

To this group belong the iron-ore deposits at Gymås, Risåsen, Norrgruvan, Gäddtjärnsberget, Njupaklitt, Kivanhoberget and Risberget,

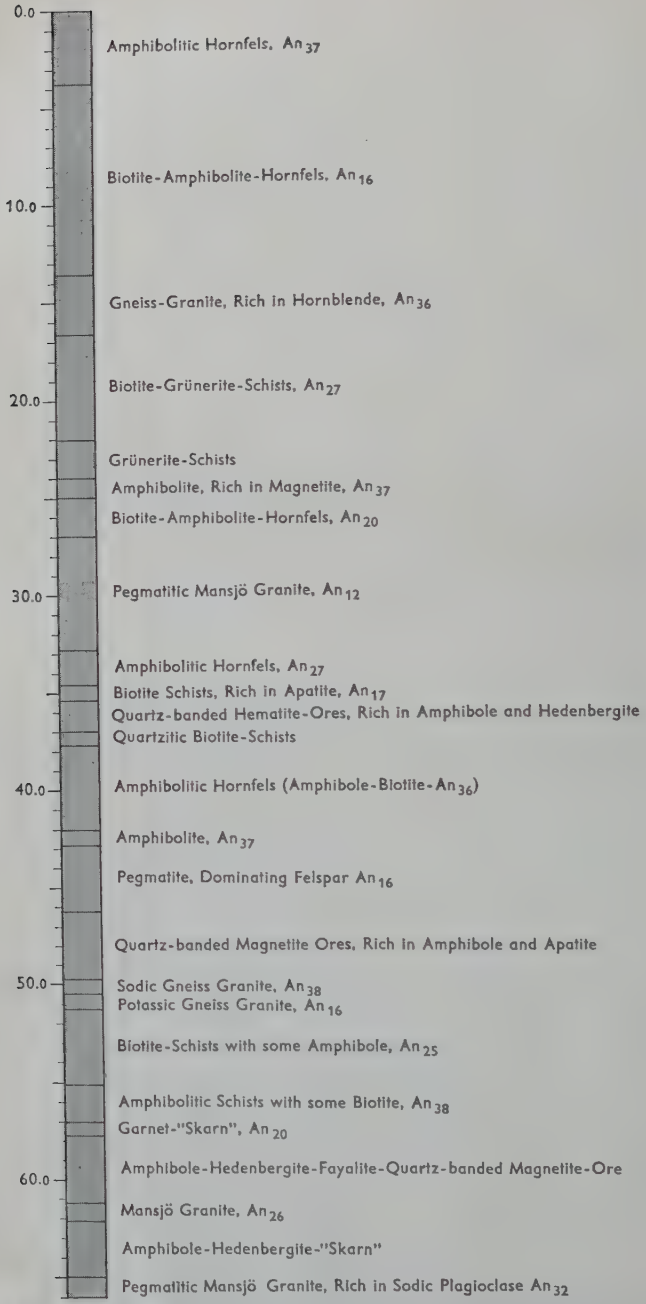
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Amphibolitic Hornfels, An$_{37}$
Biotite-Amphibolite-Hornfels, An$_{16}$
Gneiss-Granite, Rich in Hornblende, An$_{36}$
Biotite-Grünerite-Schists, An$_{27}$
Grünerite-Schists
Amphibolite, Rich in Magnetite, An$_{37}$
Biotite-Amphibolite-Hornfels, An$_{20}$
Pegmatitic Mansjö Granite, An$_{12}$
Amphibolitic Hornfels, An$_{27}$
Biotite Schists, Rich in Apatite, An$_{17}$
Quartz-banded Hematite-Ores, Rich in Amphibole and Hedenbergite
Quartzitic Biotite-Schists
Amphibolitic Hornfels (Amphibole-Biotite-An$_{36}$)
Amphibolite, An$_{37}$
Pegmatite, Dominating Felspar An$_{16}$
Quartz-banded Magnetite Ores, Rich in Amphibole and Apatite
Sodic Gneiss Granite, An$_{38}$
Potassic Gneiss Granite, An$_{16}$
Biotite-Schists with some Amphibole, An$_{25}$
Amphibolitic Schists with some Biotite, An$_{38}$
Garnet-"Skarn", An$_{20}$
Amphibole-Hedenbergite-Fayalite-Quartz-banded Magnetite-Ore
Mansjö Granite, An$_{26}$
Amphibole-Hedenbergite-"Skarn"
Pegmatitic Mansjö Granite, Rich in Sodic Plagioclase An$_{32}$

Fig. 4. Sectional Diagram of drill-hole through the Gymåsberget Iron Mine.

e graphite schists at S. Svensbo, and the eulysite-limestone series
Mansjö Mt. and Loberget.

The iron-ore leptites of the three localities first-named are typically
artz-banded magnetite or hematite ores of the usual Central Swedish
pes, the quartz bands sometimes being partly or wholly displaced
»skarn»-minerals, such as hedenbergetic pyroxenes and green horn-ende. When making a drill-hole through the Gymås-ore deposit
ig. 4), the author encountered a layer of alternating fayalite and

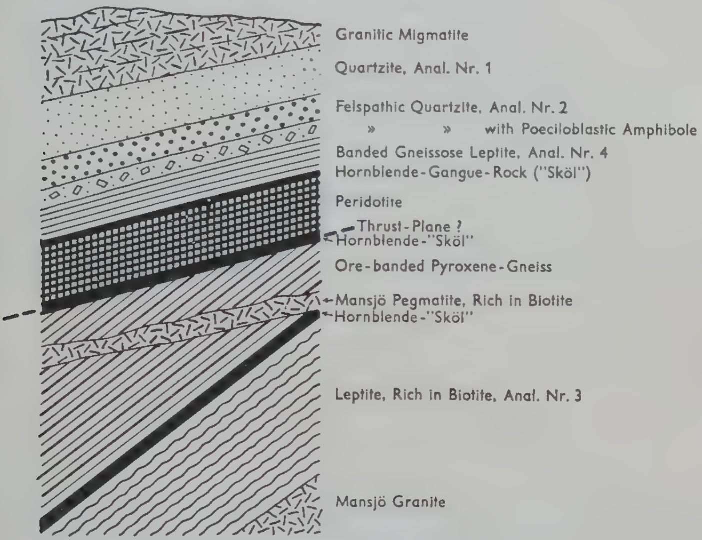
Granitic Migmatite
Quartzite, Anal. Nr. 1
Felspathic Quartzite, Anal. Nr. 2
» » with Poeciloblastic Amphibole
Banded Gneissose Leptite, Anal. Nr. 4
Hornblende-Gangue-Rock ("Sköl")
Peridotite
Thrust-Plane ?
Hornblende-"Sköl"
Ore-banded Pyroxene-Gneiss
Mansjö Pegmatite, Rich in Biotite
Hornblende-"Sköl"
Leptite, Rich in Biotite, Anal. Nr. 3
Mansjö Granite

Fig. 5. Section of the Gäddtjärn series.

gnetite, reminding one of the eulysite of Mansjön, garnet being
sent, however.

Several small pure fayalite-quartz veins were also traversed by the
ill. They proved to be of the same type as those previously found
outcrops and described by the present author in his Mansjö memoir
evidence of a late magmatic origin of the eulysite. They will be further
cussed below. The record of the drill core given in Fig. 4 furnishes
idea of the average composition and stratification of the Gymås
-bearing leptites.

The leptite formation at Gäddtjärnsberget and Njupaklitt is some-
at different. Its tectonic emplacement has already been mentioned
the previous pages (cf. p. 136) and an approximate diagram of
sequence is given in Fig. 5. The uppermost part of the sedimenta-
n series is occupied by quartzite (Analysis No. 1). This rock is

Analysis Nr. 1.

Quartzite from Njupaklitt (Wx - 230).[1]

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Actual mineral composition %	
SiO_2	87.27	145.31	Quartz . .	80.9
TiO_2	0.44	0.55	Chlorite .	9.3
P_2O_5	0.07	0.05	Muscovite.	6.6
Al_2O_3	5.98	5.87	Albite . .	2.2
Fe_2O_3	0.25	0.16	Ores . . .	0.8
FeO	3.01	4.19	Apatite. .	0.2
MnO	0.00	—		100.0
MgO	0.80	1.98		
CaO	0.09	0.16		
Na_2O	0.26	0.42		
K_2O	0.78	0.83		
$H_2O^{+105°}$	1.01	5.61		
$H_2O^{-105°}$	0.00	—		
	99.96	Sp. gravity $^{20°}_{4°}$ C: 2.681		

Analysis Nr. 2.

White Quartzite, rich in Plagioclas
Gäddtjärn Mine (Wx - 274).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual minera composition %	
SiO_2	86.31	143.71	Quartz . .	66.
TiO_2	tr.	—	Plagioclase	
P_2O_5	0.08	0.06	$(Ab_{67}An_{33})$	30.
Al_2O_3	7.58	7.45	Biotite . .	2.
Fe_2O_3	0.09	0.06	Apatite. .	0.
FeO	0.40	0.56		100.
MnO	tr.	—		
MgO	0.12	0.30		
CaO	2.49	4.44		
Na_2O	2.42	3.90		
K_2O	0.35	0.37		
$H_2O^{+105°}$	0.15	0.83		
$H_2O^{-105°}$	0.02			
	100.01	Sp. gravity $^{20°}_{4°}$ C: 2.65		

Analysis Nr. 3.

Spotty Leptite, rich in Biotite. Gäddtjärn Mine (Wx - 279).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	64.36	107.16	Q . . .	20.54	Plagioclase		qz .	+ 69
TiO_2	0.62	0.78	Or . . .	11.10	$(Ab_{60}An_{40})$.	55.6	si .	. 237
P_2O_5	0.21	0.15	Ab . . .	31.42	Quartz . . .	25.4	ti . .	1.7
Al_2O_3 . . .	19.85	19.47	An . . .	24.18	Biotite	15.0	al . .	43.0
Fe_2O_3 . . .	0.17	0.11	C . . .	2.85	Sillimanite . .	3.3	fm . .	19.5
FeO	1.17	1.63	Σ sal . .	90.09	Apatite . . .	0.7	c . . .	20.5
MnO	0.01	0.01	Hy . . .	7.86		100.0	alk . .	17.0
MgO	2.78	6.89	Mt . . .	0.25			mg . .	0.7
CaO	5.21	9.29	Hm . .	1.20			k . . .	0.2
Na_2O	3.70	5.97	Ap . . .	0.55			c/fm .	1.0
K_2O	1.85	1.96	Σ fem .	9.86				
$H_2O^{+105°}$ . .	0.15	0.83	H_2O . .	0.15				
				100.10				
	100.08	Quantitative System: I: 4: 3: 4 — *Yellowstonose.*						
$H_2O^{-105°}$ . .	0.05	Or: Ab: An — 16.64: 47.11: 36.25.						
	100.13	Sp. gravity $^{20°}_{4°}$ C: 2.702.						

entirely recrystallised and overlies a felspathic quartzite (Analy
No. 2), containing about 30 % andesinic plagioclase, An_{37}, so
reddish-brown biotite and poeciloblastic cummingtonitic amphibo
$[(\gamma - \alpha)_{550} = 0.033;\ 2V_{550} = 80°;\ c/\gamma = 13°]$.

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[1] The numbers within brackets refer to the specimens of my collection.

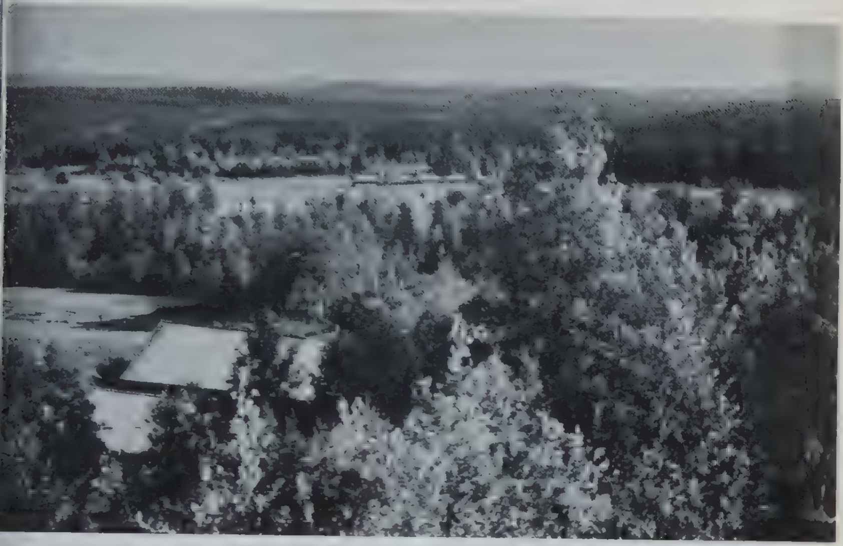


Fig. 1. View from the watch-tower of Ryggskog towards the eastern archæan hills.

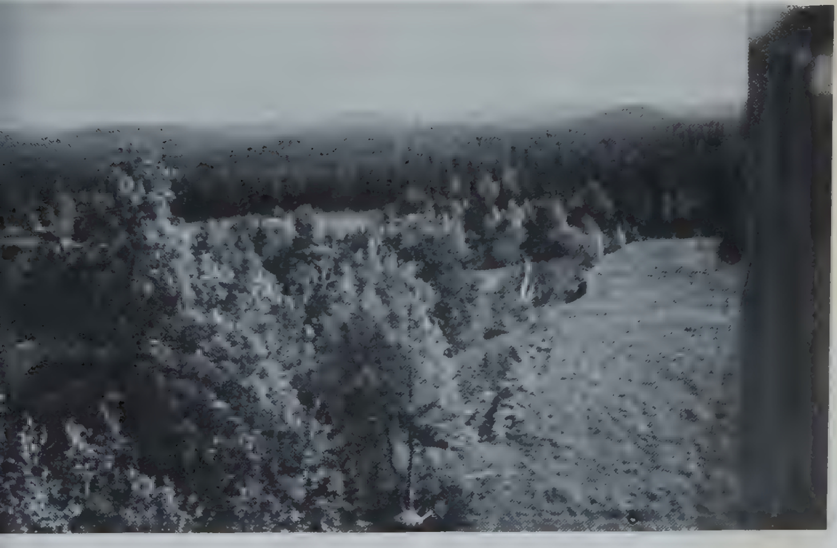
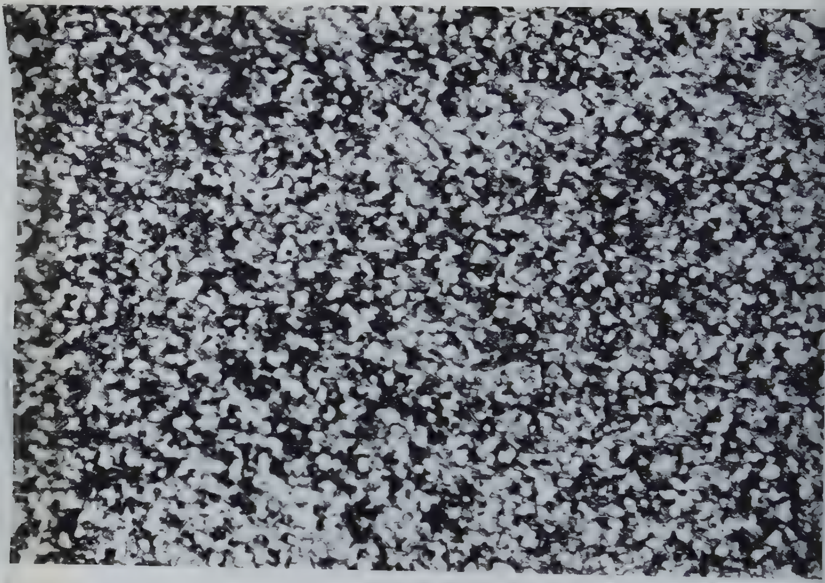
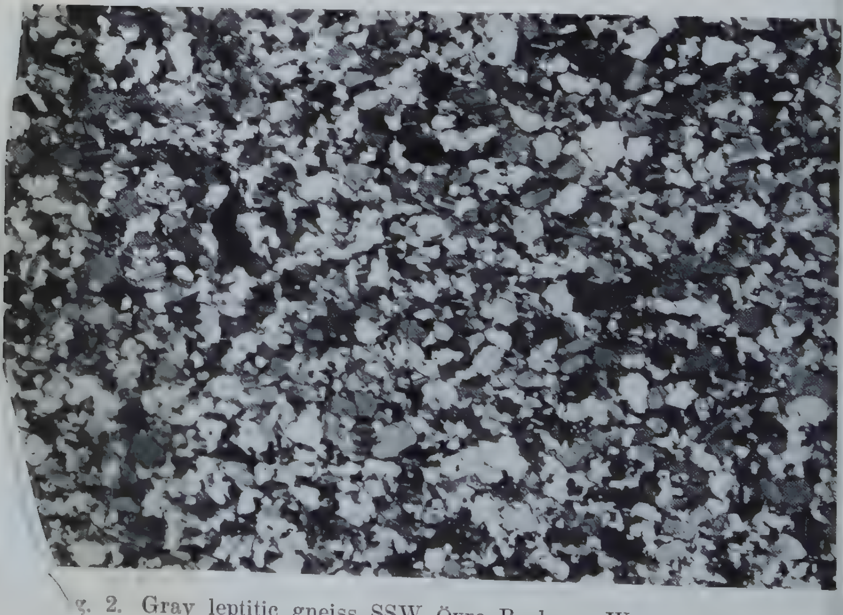


Fig. 2. View from the watch-tower of Ryggskog towards the south
greenstone hillocks. Older Loos quartzite of the foreground rests unconf
ably on Loos quartz-porphyries in the middle distance.



ig. 1. Fine-grained leptitic sediment at Gäddtjärn, Woxna. Ord. light. Magnif. × 10.



g. 2. Gray leptitic gneiss SSW Övre Broberg, Woxna. Nic. +. Magnif. × 10.

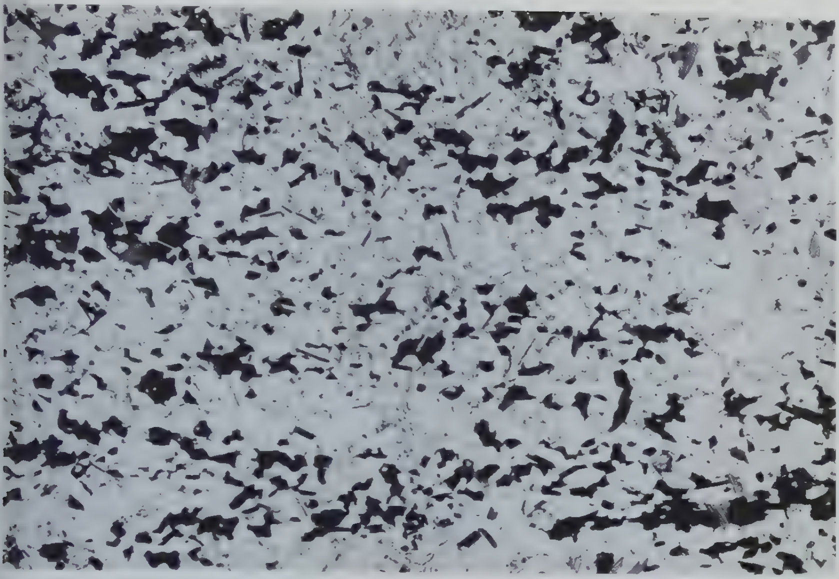


Fig. 1. Banded gray migmatitized leptite. W side of Fetingsklacken E of Loos. Ord. light. Magnif. × 10.

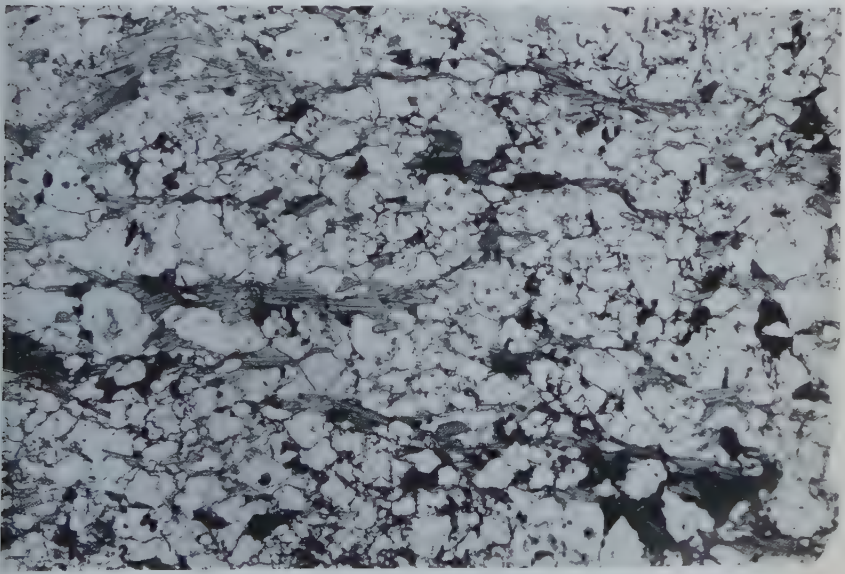


Fig. 2. Migmatitized leptite at Nilsberget W of Lobonäs. Ord. light. Magnif. × 10.

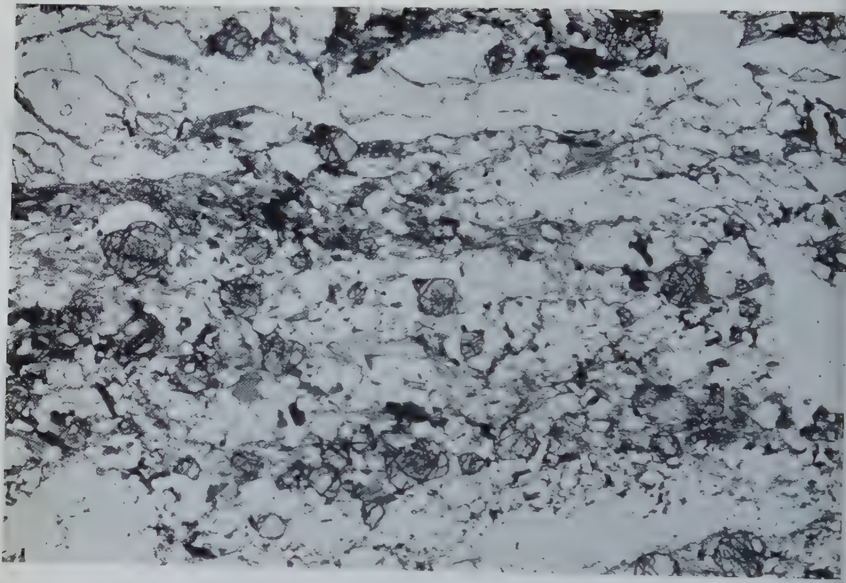


Fig. 1. Dark-grey migmatitic garnet-gneiss. Crest of Selmaberget. Ord. light. Magnif. × 10.

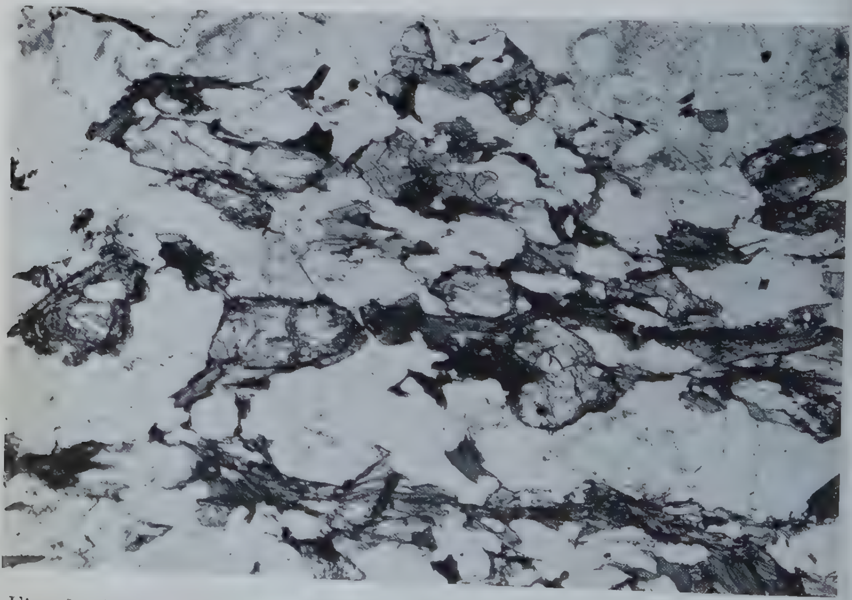
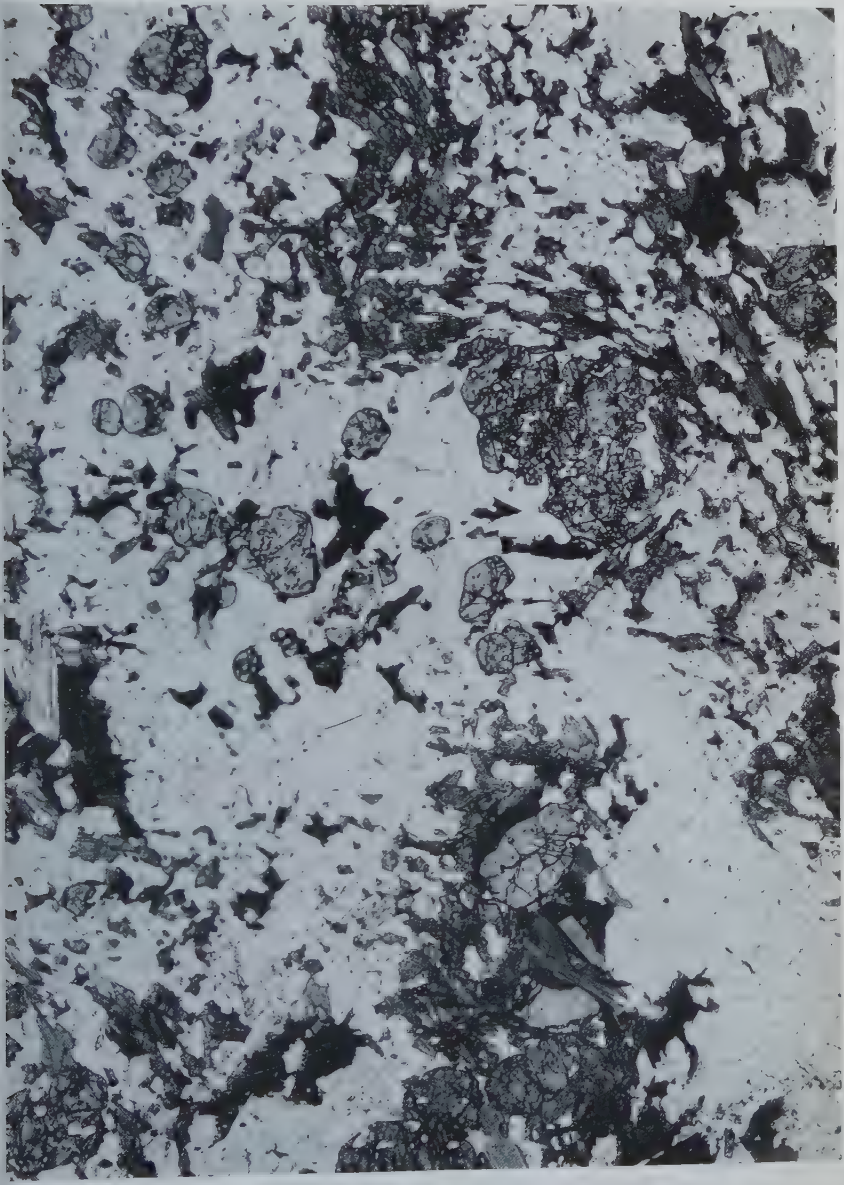
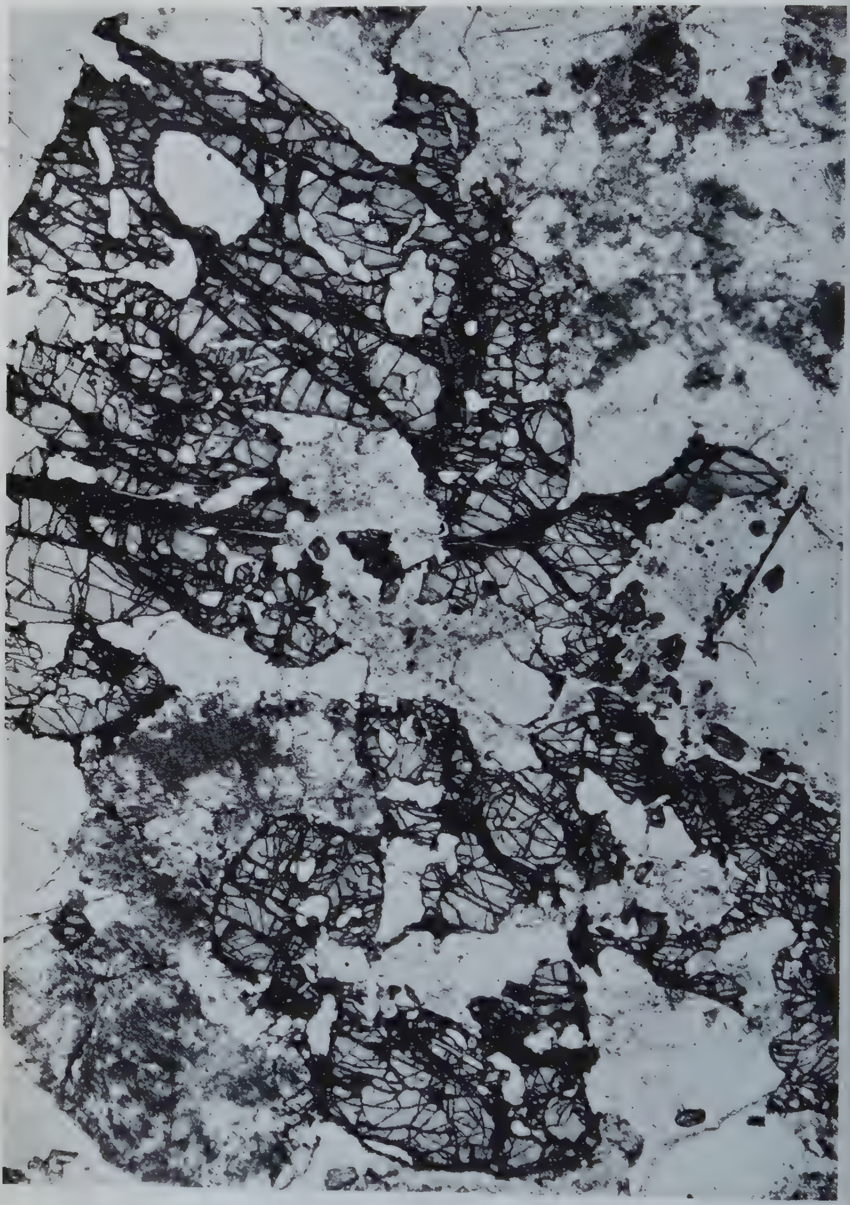


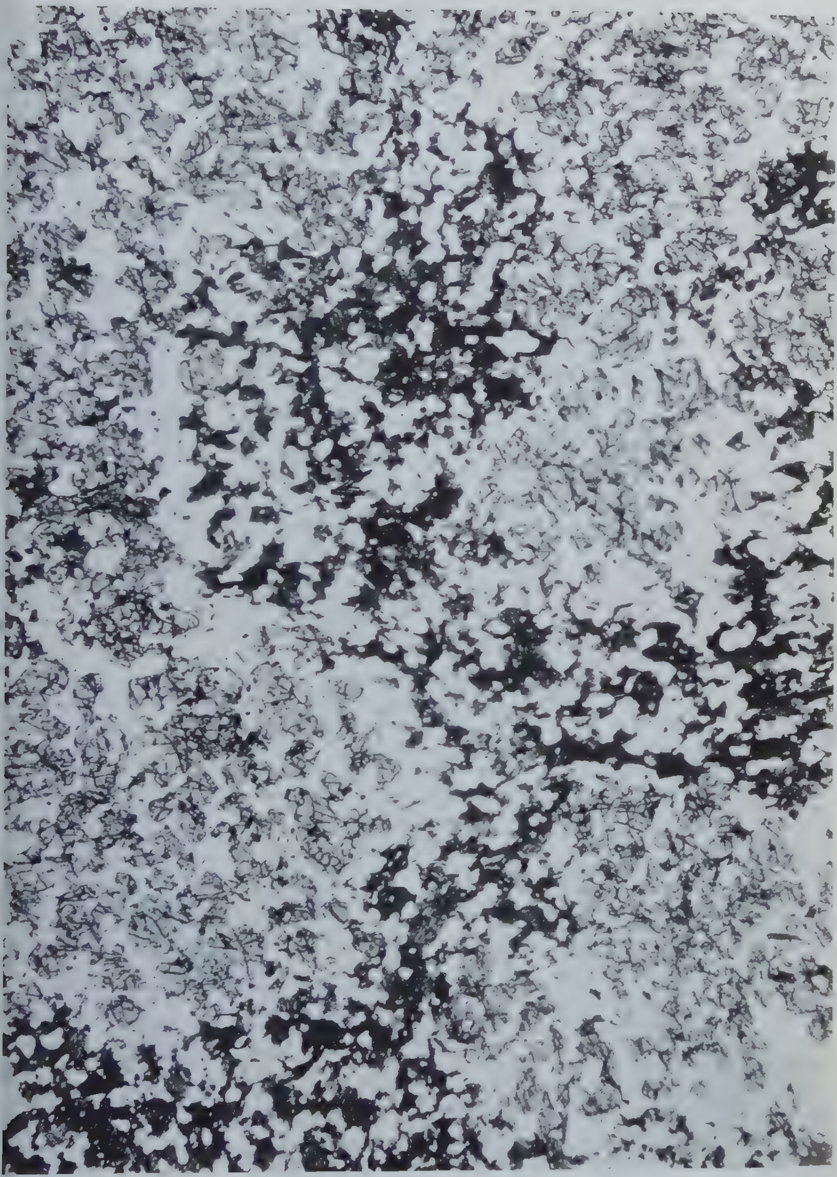
Fig. 2. Gray garnet-gneiss. SSW of Lilleisjön. Ord. light. Magnif. × 10.



Garnet-gneiss with remains of primary banding of migmatitized leptite.
Vintjärn, Woxna. Ord. light. Magnif. × 10.



Very coarse garnet-gneiss. All traces of the primary features of the leptite are obliterated. Secondary chloritization of the garnet along the cleavages. Ord. light. Magnif. × 10.



»Eclogitic» migmatite at Nilsberget, W of Lobonäs. Round, composite grains of pink garnet (light-gray) and quartz (white) lie in a base of green hornblende (dark) and plagioclase. Ord. light. Magnif. × 10.

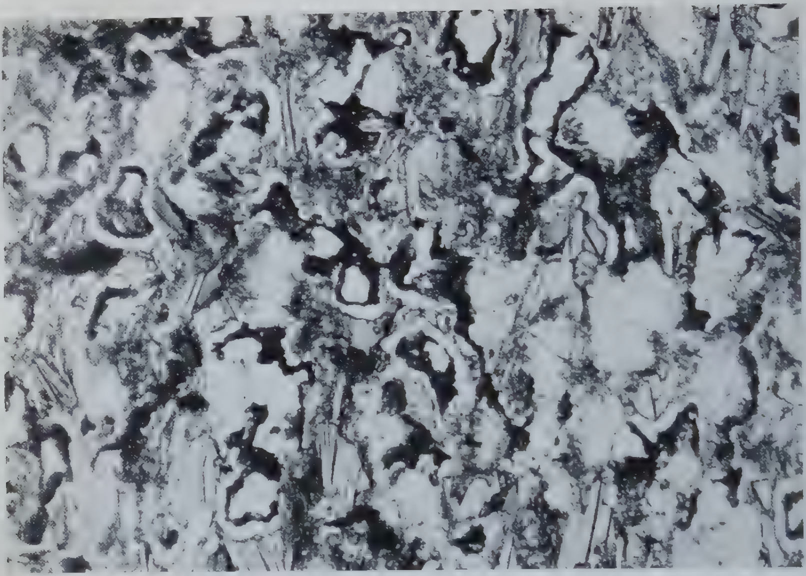


Fig. 1. Fine-grained leptite-inclusion in Mansjö granite. Amphibole-rims (dark) surrounding the quartz-grains. Ord. light. Magnif. × 55.

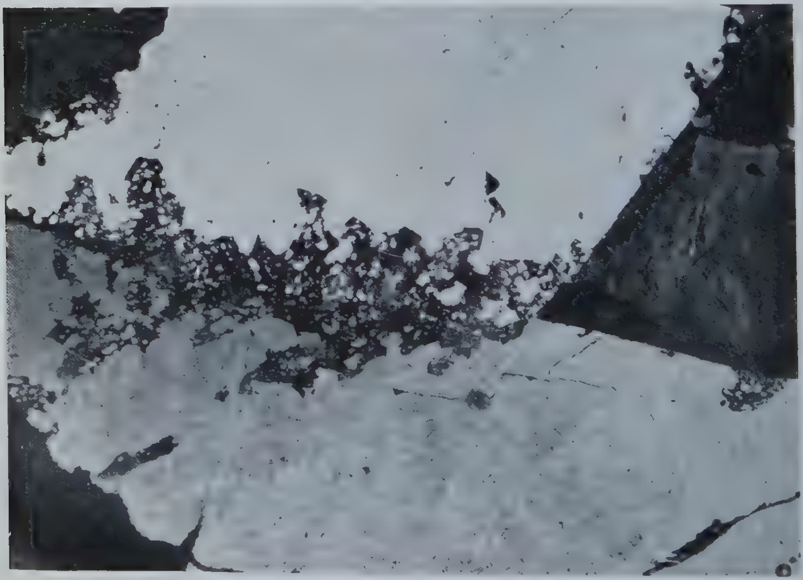


Fig. 2. »Breccia»-pegmatite at Broberg, Woxna. Optically homogeneously oriented pink microcline occurs as a net-like growth (centre of picture) independently of the joints between the quartz-grains. Nic. +. Magnif. × 10.

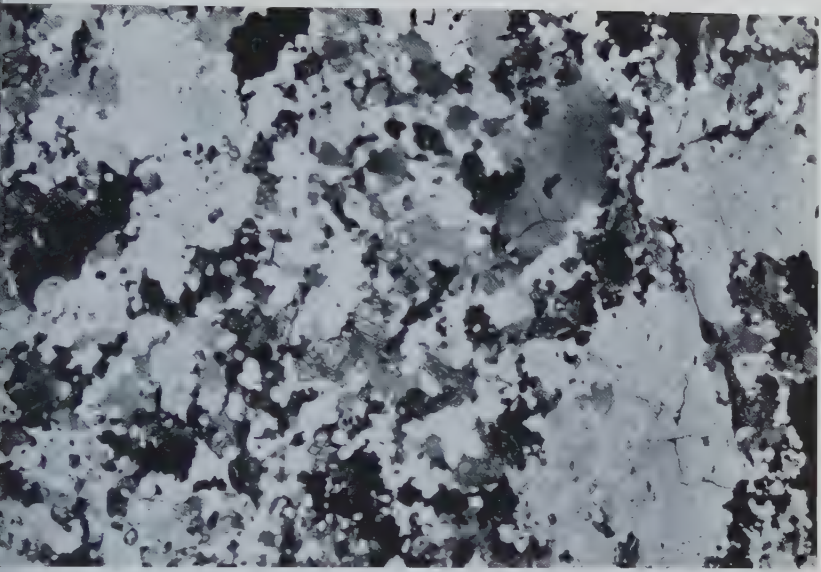


Fig. 1. Quartzite within the Leptite Series of Gäddtjärnsberget, Woxna. Nic. +. Magnif. × 10.

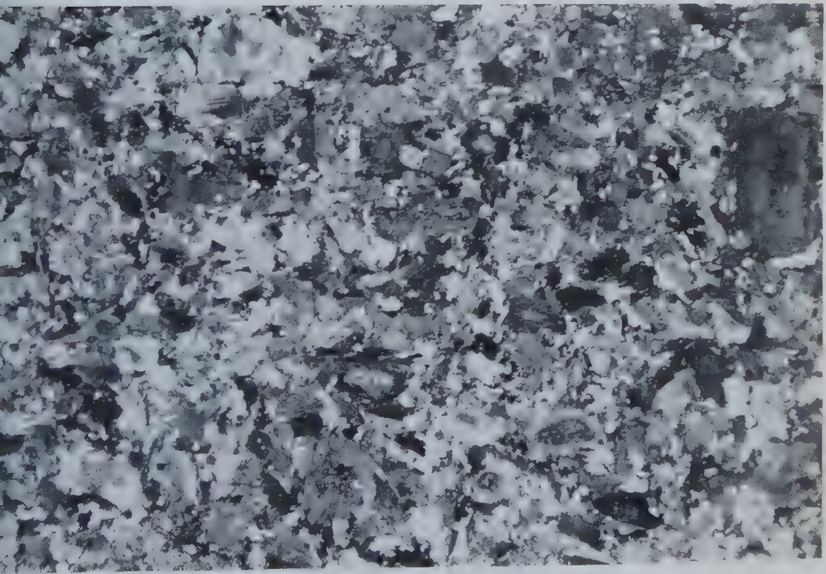


Fig. 2. Migmatitic leptite at Fageråskölen. Nic. +. Magnif. × 10.

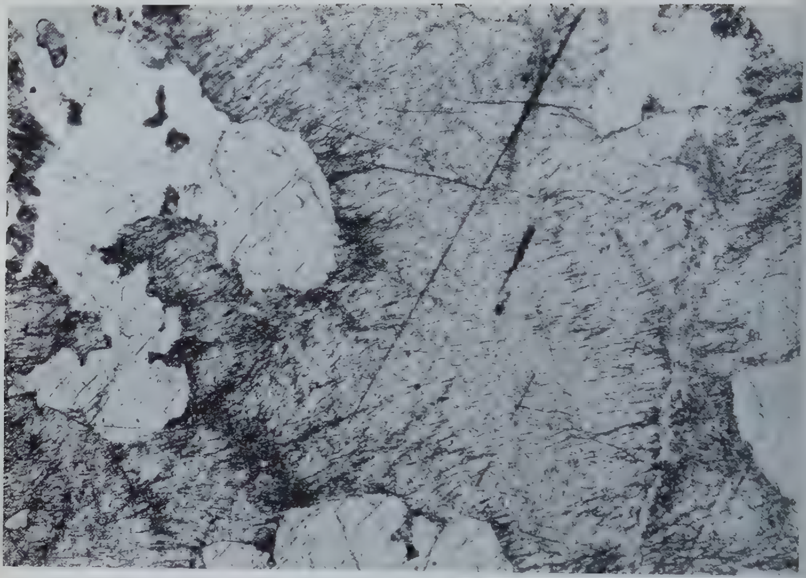


Fig. 1. Microcline filled with rutile-microlites. Pegmatite associated with the Hylen granite (Group I). Ord. light. Magnif. × 10.

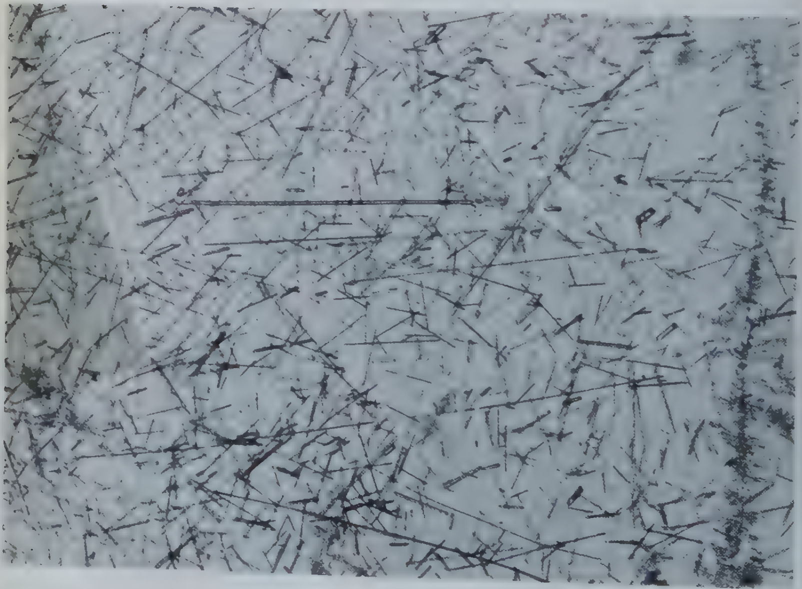
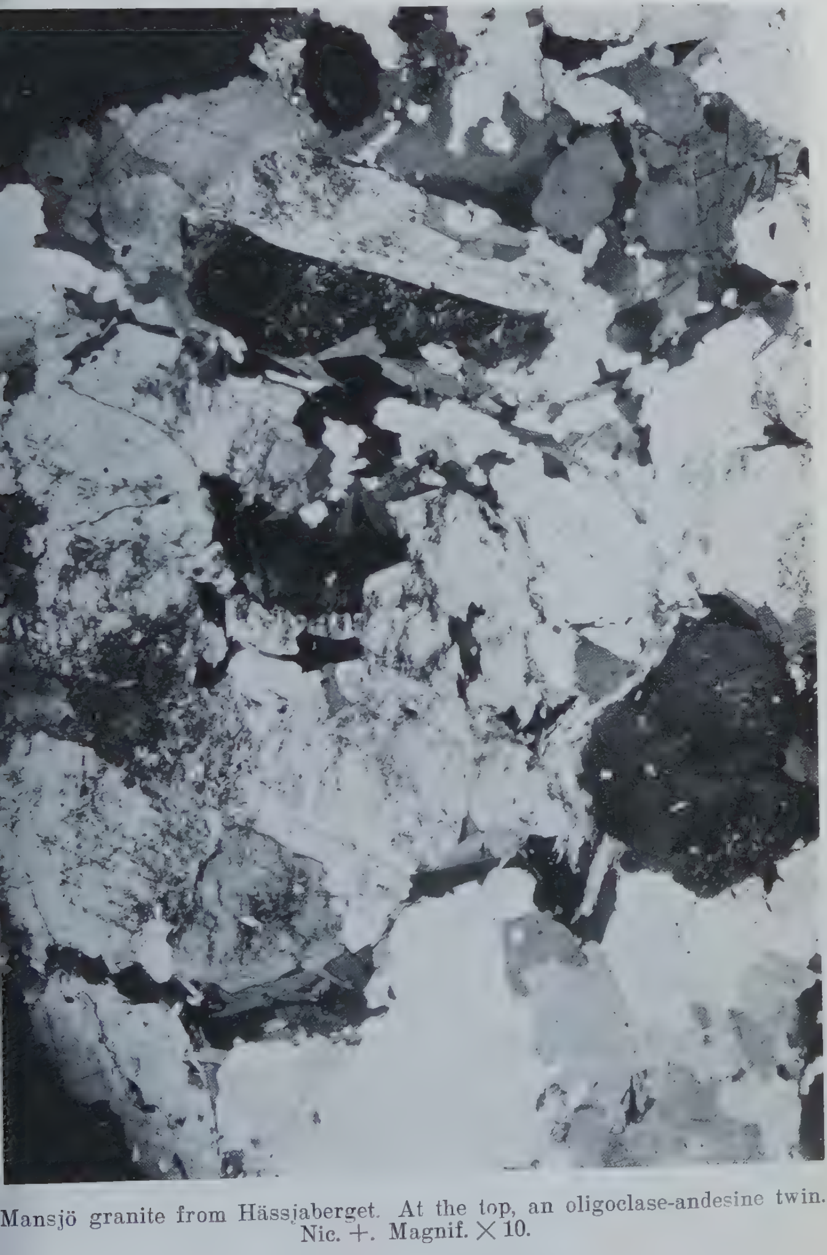


Fig. 2. The same as Fig. 1, at higher magnification. Ord. ligh. Magnif. × 55.



Mansjö granite from Hässjaberget. At the top, an oligoclase-andesine twin.
Nic. +. Magnif. × 10.

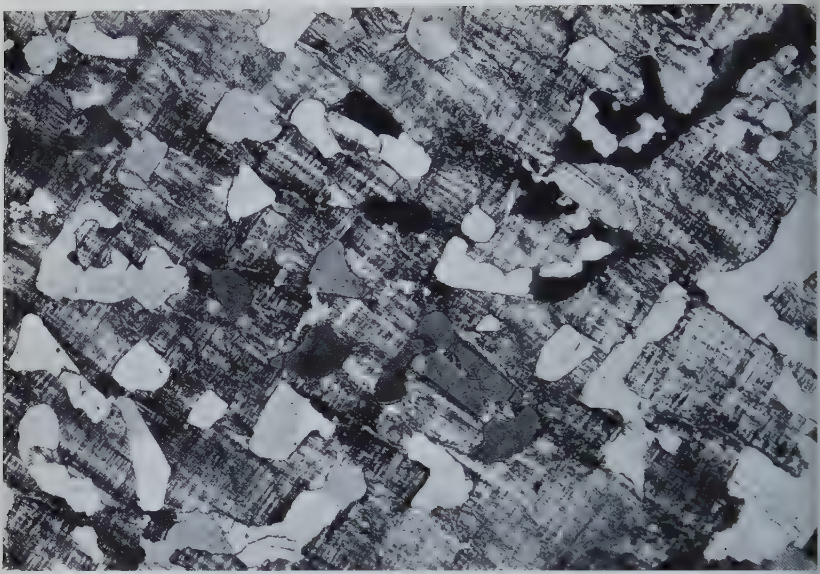


Fig. 1. Implication-structured microcline of the migmatites east of Svensbo. Nic. +. Magnif. × 10.

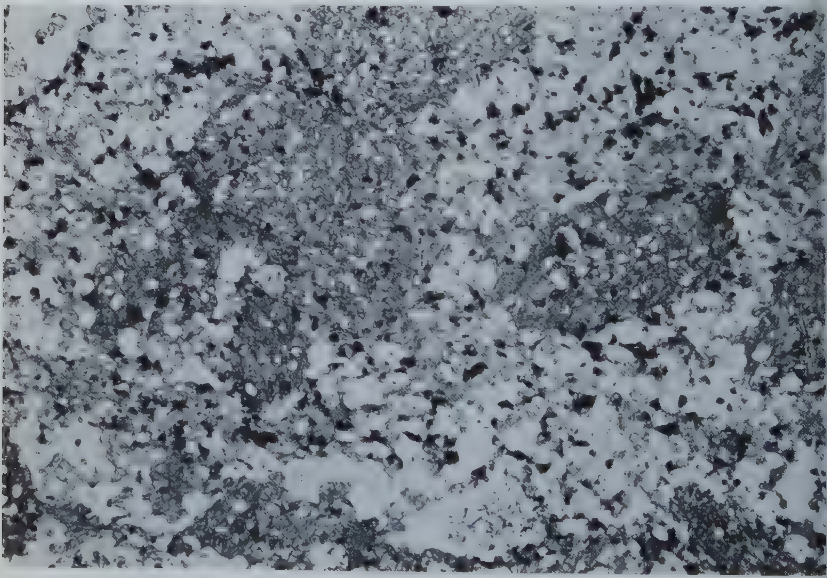
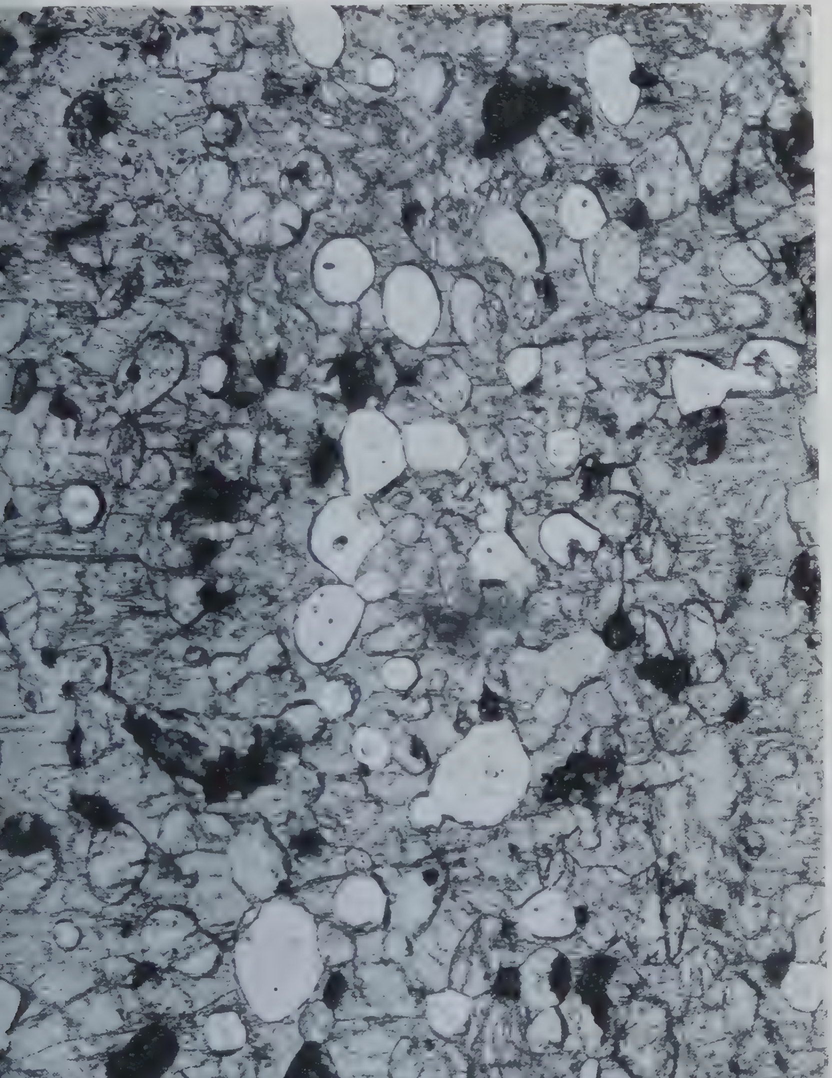
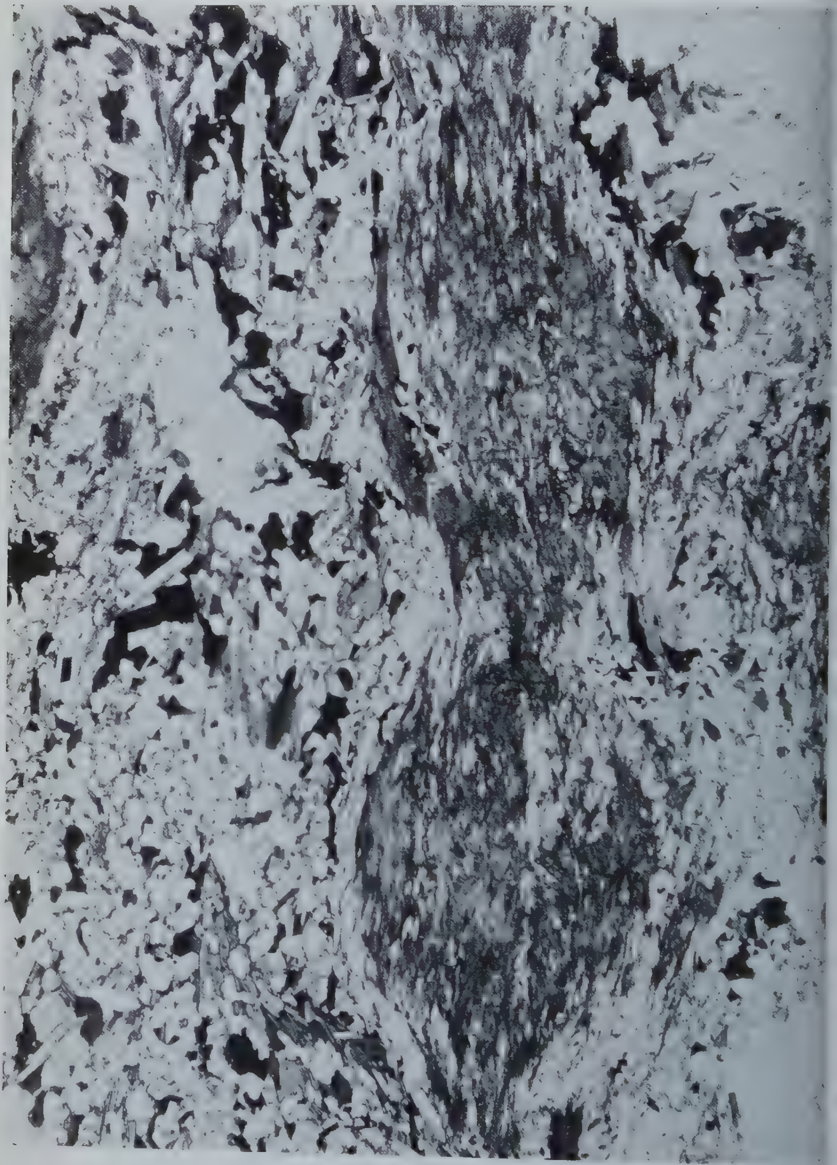


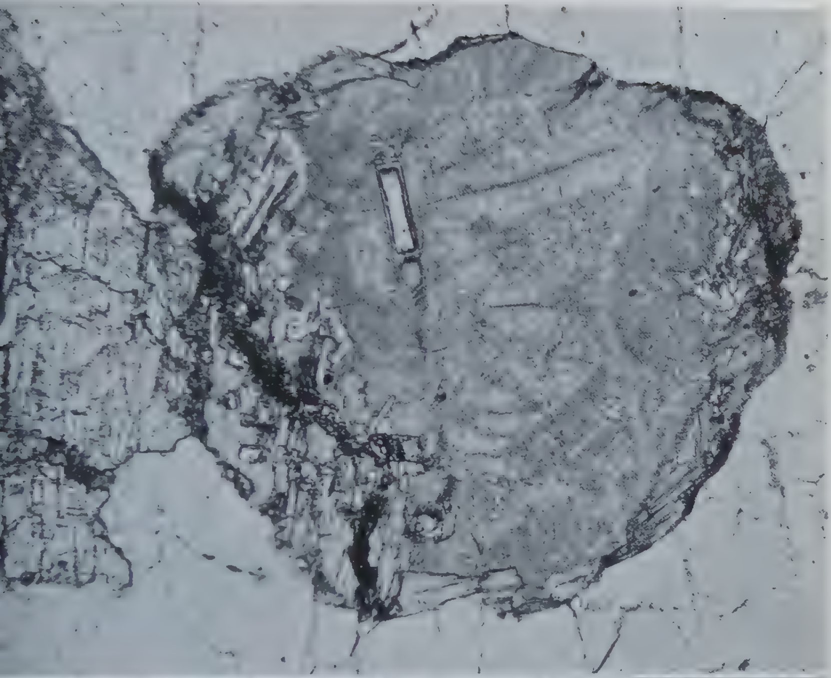
Fig. 2. »Spotty» leptite at Gäddtjärn, Woxna. Poeciloblastic amphiboles. Ord. light. Magnif. × 10.



Poeciloblastic amphibole of »spotty» leptite at Gäddtjärn.
Ord. light. Magnif. × 55.



Lenticular streaks of sillimanite in migmatite SW of Lake Dåasen. Ord. light. Magnif. × 10.



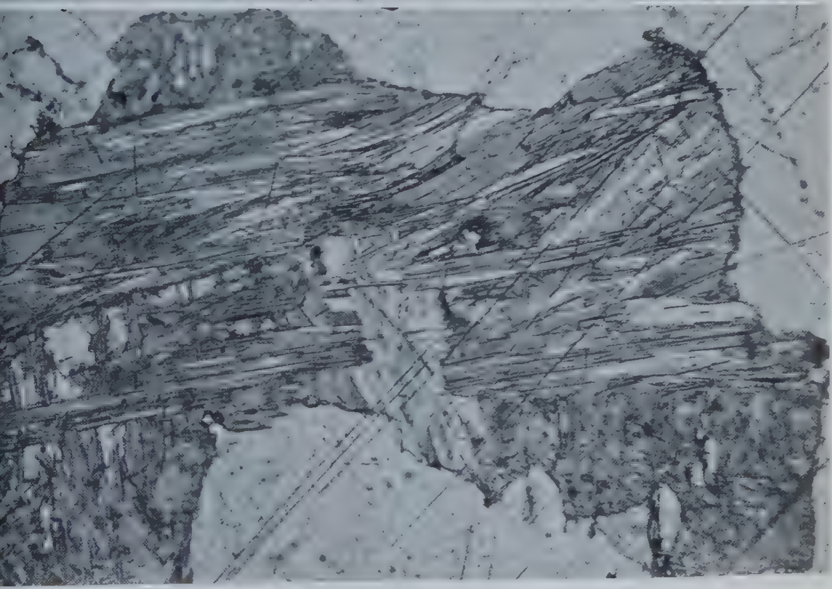
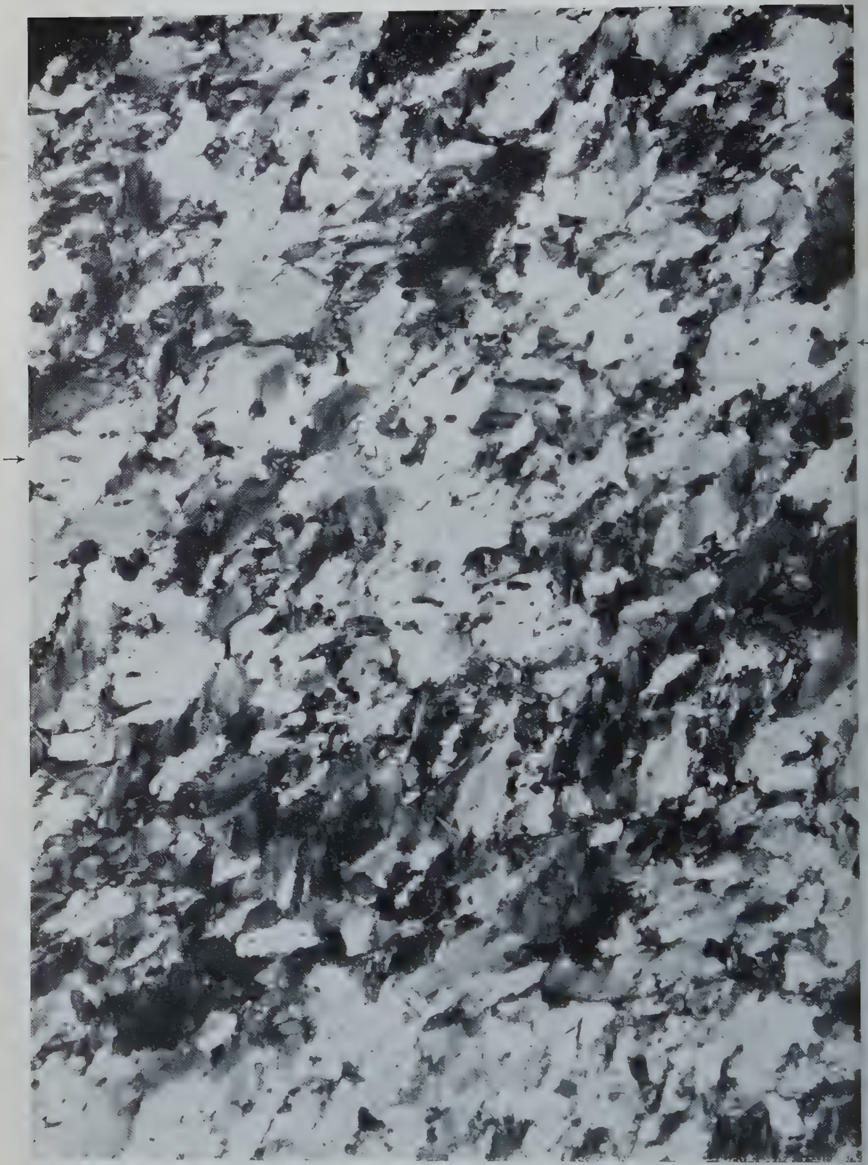


Fig. 1. Cordierite-pseudomorph from gneiss-granite at Enfotaberget, Woxna. The cordierite is altered into a green isotropic substance. To the left, andalusite.

Fig. 2. Cordierite-pseudomorph from Älgkosberget, Woxna. The cordierite is altered into green chlorite (upper centre, bottom right and left) and actinolitic amphibole (centre). Ord. light. Magnif. × 35.



Plicated Sub-Loosian quartzite at Storkvarnberget. Small gray grains (for instance in the centre [left arrow] and to the right [right arrow]) are tourmaline, which is almost the only mineral occurring besides quartz.
Nic. +. Magnif. × 10.

Analysis Nr. 4.

Banded Gneissose Leptite. Gäddtjärn Iron Mine (Wx - 271).

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Norm		Actual mineral composition %		Niggli's System	
SiO$_2$	65.71	109.41	Q	22.16	Plagioclase		qz	+ 77
TiO$_2$	1.45	1.82	Z	0.91	(Ab$_{86}$An$_{14}$)	30.0	si	291
P$_2$O$_5$	0.10	0.07	Or	31.76	Quartz	27.8	ti	4.83
Al$_2$O$_3$	18.25	17.90	Ab	26.20	Microcline	13.9	al	47.5
Fe$_2$O$_3$	0.26	0.16	An	3.58	Sericite	9.4	fm	19.5
FeO	1.35	1.88	C	6.01	Biotite	6.0	c	4.5
MnO	0.01	0.01	Σ sal	90.62	Sillimanite	5.4	alk	28.5
MgO	2.09	5.18	Hy	5.21	Cordierite	3.6	mg	0.70
CaO	0.88	1.57	Mt	0.20	Titano-magnetite	2.8	k	0.53
Na$_2$O	3.08	4.97	Hm	0.13	Zircone	0.9	c/fm	0.25
K$_2$O	5.41	5.74	Ilm	2.73	Apatite	0.2		
H$_2$O$^{+110°}$	0.66	3.66	Ap	0.28		100.0		
ZrO$_2$	0.61	0.50	Σ fem	8.55				
			H$_2$O	0.66				
				99.83				
H$_2$O$^{-110°}$	0.18							
	100.04							

Quantitative System: I: 2: 2: 3 — No name.
Or: Ab: An — 51.61: 42.57: 5.82.
Sp. gravity $\frac{20}{4°}$ C: 2.670.

Immediately below, and at the bottom of the series, follows a spotted
banded gneissose rock which undoubtedly constitutes a highly meta-
orphic sediment. Its mode is given by analyses No. 4 and 3, re-
ectively, the rock being conspicuous by its excessive alumina and a
gh percentage of mica, sillimanite, cordierite, titano-magnetite and
rcon. The ores and the zircon are oriented in layers, indicating a
imary sedimental concentration of heavy minerals derived from older,
mpletely broken down, rocks of unknown origin.

The peridotite underbedding the leptite sediment and separated
om it by a »skarn» zone, does not show any relics of original bedding.
may originally have been a basic dyke possibly connected with the
rzburgitic dyke of Mansjö.

A part-replacement of the olivine by serpentine and amphibole is
obably due to the accession of solutions from the granite. The perido-
e overlies unconformably the stratified rocks composing the base
the series. The upper part of these rocks may be termed pyroxene
eisses, the dominating minerals being a hedenbergitic diopside, green
rnblende, bands of iron-ore and some beautifully green spinell.
ey may constitute calcareous sediments, rich in iron, in an ad-
nced stage of metamorphism. They are intersected by pegmatites
the Mansjö granite exhibiting large biotite crystals, and are very

similar to the corresponding dykes of Mansjö Mt. The basal rock are the leptites of analysis No. 3.

The strong pneumatolytic influence of the Mansjö granite is strikingl illustrated by the biotitic leptites at the top of the series, where, clos to the granitic contacts, the composition is as follows: plagioclas An_{56-57}, faint yellowish-brown biotite, spots of leucoxene, some quart and numerous tourmaline crystals. This tourmaline is of an unusua pleocroic colour, ranging from almost colourless to honey-yellow, feature previously observed by the author within the leptites of Hamrånge on the Baltic E. Coast (cf. 3 p. 317).

The pneumatic influence of the granite on the leptites is also apparent by the formation of graphite-bearing schists at S. Svensbo, previously described by the author. Two recalculated analyses, Nos. 5—6 from the writer's previous paper on the said locality are given, as the represent roughly the same variation in mineral and plagioclase composition as the analyses of the Gäddtjärn rocks, Nos. 4 and 1 respectivel They are the exponents of two different metamorphic phases, th »biotite-microcline-basic plagioclase», and the »chlorite-biotite-acid plagioclase», which may be supposed to have originated from a correspondin primary chemical variation in the sedimentation.

The plagioclase composition of the former type ranges from An_3—An_1 and of the second type from An_{33}—An_{48}, the leptites being at the sam time dominatingly potassic or sodic, respectively. Sometimes th plagioclase has been observed to be as basic as An_{67}. The basic leptite grade into amphibolites, as demonstrated by Analyses Nos. 7— such amphibolites being found as lenticular streaks within the migmatites, or as layers within the Mansjö syncline. They may originall be either basic sediments or highly metamorphosed intrusive dyke contemporaneous with the amphibolitic dykes of Central Sweden succeeding the first orogenetic and metamorphic activity of the oldes granites. They are never observed cutting the succeeding granite o Group II. When migmatitized they are sometimes altered into »eclogitic» rocks or develop strange hornblende-rims around the quartz grains (Pl. VII and Pl. VIII, Fig. 1).

Finally, there may be mentioned the limestone-eulysite synclinea leptitic fragments of Mansjö and Loberget. A detailed account of Mansjö has previously been published (2), and the Loberget occurrenc has been found to be in every respect quite similar to it. The write would like to avail himself of this opportunity, however, to rectif an earlier conception of his regarding the origin of the eulysites, whic he formerly considered to be pegmatitic hydatogeneous and halogeneous residual solutions of basic magma. The drill cores from Gymås

Analysis Nr. 5.

Graphite-bearing Leptite. Svensbo.

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
iO$_2$	75.43	125.59	Q . . .	52.60	Quartz . . .	53.9	qz .	+297
iO$_2$	0.00	—	Or . . .	9.96	Plagioclase		si .	. 481
$_2$O$_5$	0.19	0.13	Ab . . .	18.84	($Ab_{84}An_{16}$) .	37.6	ti . .	0.00
l$_2$O$_3$ . . .	10.88	10.67	An . . .	5.29	Chlorite . . .	3.0	al . .	41.0
e$_2$O$_3$ . . .	1.88	1.18	C . . .	3.47	Zoisite . . .	1.2	fm . .	29.0
eO	2.61	3.63	Σ sal . .	90.16	Pyrites . . .	2.9	c . .	9.0
nO	0.03	0.04	Hy . . .	2.38	Graphite . . .	1.0	alk . .	21.0
gO	1.09	1.54	Mt . . .	2.75	Apatite . . .	0.4	mg . .	0.20
aO	1.30	2.32	Py . . .	2.86		100.0	k . .	0.33
a$_2$O . . .	2.21	3.56	Ap . . .	0.40			c/fm .	0.31
$_2$O	1.65	1.75	Σ fem .	8.39				
$_2$O$^{+105°}$ . .	1.07	5.94	H_2O . .	1.07				
. . . . .	1.34	4.18	C . . .	0.99				
. . . . . .	0.99	—		100.61				
	100.67							
- O = S . .	0.50							
$_2$O$^{-105°}$ . .	0.33							
	100.50							

Quantitative System: I: 3: 2: 4 — *Aisbachose*
Or: Ab: An — 29.22: 55.26: 15.52.
Sp. gravity $\frac{20°}{4°}$ C = 2.681.

Analysis Nr. 6.

Sillimanite-gneiss (Sodic biotite-leptite). Södra Svensbo.

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
iO$_2$	62.13	103.45	Q . . .	13.03	Quartz . . .	18.2	qz .	+ 65.5
iO$_2$	0.15	0.19	Or . . .	13.89	Plagioclase		si .	. 249.5
$_2$O$_5$	0.23	0.16	Ab . . .	39.81	($Ab_{52}An_{48}$) .	60.1	ti . .	0.33
l$_2$O$_3$ . . .	21.38	20.97	An . . .	20.86	Microcline . .	1.8	al . .	44.5
e$_2$O$_3$ . . .	0.64	0.40	C . . .	3.46	Biotite . . .	11.5	fm . .	17.5
eO	0.84	1.17	Σ sal . .	91.05	Sillimanite . .	7.2	c . .	17.0
nO	0.01	0.01	Hy . . .	6.23	Apatite . . .	0.5	alk . .	21.0
gO	2.51	6.22	Mt . . .	0.88	Pyrites . . .	0.7	mg . .	0.76
aO	4.49	8.00	Ilm . .	0.29		100.0	k . .	0.25
a$_2$O . . .	4.68	7.55	Py . . .	0.83			c/fm .	0.98
$_2$O	2.33	2.47	Ap . . .	0.51				
$_2$O$^{+105°}$ . .	0.73	4.05	Σ fem .	8.74				
. . . . . .	0.41	1.28	H_2O . .	0.73				
				100.52				
	100.53							
O = S . .	0.15							
$_2$O$^{-105°}$ . .	0.16							
	100.54							

Quantitative System: I: 4: 3: 4 — *Yellowstonose.*
Or: Ab: An — 18.73: 53.39: 27.98.
Sp. gravity $\frac{20°}{4°}$ C = 2.666.

Analysis Nr. 7.

Amphibolitic leptite-gneiss. Södra Svensbo.

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	69.59	115.87	Q	33.88	Quartz	38.3	qz	+140
TiO_2	0.50	0.62	Or	9.99	Plagioclase		si	296
P_2O_5	0.21	0.15	Ab	19.38	($Ab_{52}An_{48}$)	37.2	ti	1.74
Al_2O_3	15.01	14.72	An	23.69	Hornblende	12.5	al	37.5
Fe_2O_3	0.31	0.19	C	0.92	Biotite	9.3	fm	26.0
FeO	1.97	2.74	Σ sal	87.86	Pyroxene	1.0	c	22.5
MnO	0.04	0.06	Hy	9.54	Titanite	0.9	alk	14.0
MgO	2.79	6.92	Ilm	0.93	Apatite and		mg	0.68
CaO	5.01	8.93	Mt	0.45	Zoisite	0.6	k	0.33
Na_2O	2.28	3.68	Ap	0.65	Pyrites	0.2	c/fm	0.88
K_2O	1.67	1.77	Σ fem	11.57		100.0		
$H_2O^{+105°}$	0.27	1.50	H_2O	0.27				
S	0.01	0.03		99.70				
$H_2O^{-105°}$	0.06							
	99.72							

Quantitative System: I: 3: 3: 4 — Rang Riesenase.
Or: Ab: An — 8.82: 36.53: 44.65.
Sp. gravity $\frac{20°}{4°}$ C = 2.682.

Analysis Nr. 8.

Amphibolitic leptite-gneiss. SE of Lake Grycken.

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	65.95	109.81	Q	31.41	Quartz	32.5	qz	+115
TiO_2	0.66	0.83	Or	8.35	Plagioclase		si	259
P_2O_5	0.25	0.18	Ab	16.80	($Ab_{54}An_{46}$)	32.5	ti	2.22
Al_2O_3	14.02	13.75	An	25.32	Biotite	22.5	al	32.5
Fe_2O_3	1.10	0.69	Σ sal	81.88	Hornblende and		fm	33.0
FeO	3.97	5.53	Hy	12.37	Pyroxene	8.6	c	23.5
MnO	0.08	0.11	Mt	1.60	Titanite	1.6	alk	11.0
MgO	2.81	6.99	Ilm	1.24	Ores	1.7	mg	0.50
CaO	5.60	9.99	Ap	0.64	Apatite	0.6	k	0.32
Na_2O	2.01	3.24	Σ fem	15.85		100.0	c/fm	0.71
K_2O	1.41	1.50	H_2O	1.86				
$H_2O^{+105°}$	1.86	10.32		99.59				
$H_2O^{-105°}$	0.10							
	99.82							

Quantitative System: II: 3: 3: 4 — *Sitkose.*
Or: Ab: An — 16.54: 33.29: 50.17.
Sp. gravity $\frac{20°}{4°}$ C = 2.861.

having disclosed an unmistakable primary banding of iron-ores an eulysitic fayalite rock, a renewed study of the Mansjö eulysite prove necessary. The latter, however, shows no banding but almost a brecciation of the gneissose leptites.

Analysis Nr. 9.

Amphibolitic Leptite-Gneiss. North of Mansjö.

Analyst: H. von Eckermann and G. Haglund.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	62.72	104.43	Q	23.96	Quartz	26.6	qz	+108
TiO_2	0.71	0.89	Or	9.58	Plagioclase		si	262
P_2O_5	0.30	0.21	Ab	23.62	($Ab_{63}An_{37}$)	37.8	ti	1.96
Al_2O_3	12.91	12.66	An	18.09	Hornblende and		al	28.0
Fe_2O_3	1.12	0.70	Σ sal	75.25	Pyroxene	15.8	fm	36.0
FeO	5.16	7.18	Di	7.23	Biotite	13.6	c	22.5
MnO	0.10	0.14	Hy	8.76	Pyrite	2.3	alk	13.5
MgO	3.50	7.69	Mt	1.62	Titanite	1.6	mg	0.47
CaO	5.76	10.27	Ilm	1.36	Ores	1.6	k	0.27
Na_2O	2.81	4.53	Pr	2.27	Apatite	0.7	c/fm	0.63
K_2O	1.62	1.72	Ap	0.69		100.0		
$H_2O^{+105°}$	2.66	14.77	Σ fem	21.93				
S	0.69		H_2O	2.66				
				99.84				
$H_2O^{-105°}$	0.21							
	99.87							

Quantitative System: II: 4: 3: 4 — *Tonalose.*
Or: Ab: An — 18.68: 46.05: 35.27.
Sp. gravity $\frac{20°}{4°}$ C = 2.885.

I have arrived at the conclusion that perimagmatic products are rtainly responsible for the origin of the eulysites, but that these oducts are derived from the Mansjö granite and not from the rest-fferentiate of a basic magma. They do not constitute the sole com-nent of the eulysites, however, but have acted as a metamorphic ent on sediments originally very poor in alkalies and lime but rich iron, such as quartzitic ore-sediments.

During the process of metamorphism, all the original quartz-ore-nding has been obliterated and an almost homogeneous rock has en formed, occasionally including fragmental relics of the older dimentation. This homogenisation must certainly indicate an intense obilisation of the molecules, probably at very high pressure as evi-nced by the formation of garnets. Consequently, I still believe at the halogeneous residuals of the pegmatitic solutions must have en an important factor of the metamorphism and that the chemical actions conceived in my previous paper (pp. 290—291) have been gely instrumental in this metamorphic evolution. The main dif-ence in the writer's present view lies in his now considering these emical reactions to have taken place autogeneously as far as the n is concerned.

The very minute quantities, or the even total absence, of chemically

Analysis Nr. 10.

Eulysite. Loberget Hill (Wx - 257).

Analyst: J. Petrén & H. von Eckermann.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	39.89	66.42	An . . .	7.40	Fayalite . . .	76.6	qz .	+730
TiO_2	0.05	0.06	Σ sal . .	7.40	Quartz . . .	12.5	si . .	830
P_2O_5	0.25	0.18	Hy . . .	58.34	Garnet . . .	9.8	ti . .	—
Al_2O_3 . . .	2.04	2.00	Ol . . .	32.30	Apatite . . .	0.6	al . .	2.5
Fe_2O_3 . . .	0.40	0.25	Mt . . .	0.62	Pyrite	0.5	fm . .	90.0
FeO	42.17	58.70	Ilm . .	0.12		100.0	c . .	7.5
MnO	6.88	9.70	Py . . .	0.23			alk . .	0.0
MgO	4.50	11.16	Ap . . .	0.57			mg . .	0.16
CaO	3.35	5.97	Σ fem .	92.18			k . .	0.0
Na_2O . . .	0.00	—		99.58			c/fm .	0.09
K_2O	0.00	—						
$H_2O^{+105°}$ . .	0.00	—						
V_2O_5	0.00	—						
Cr_2O_3 . . .	0.00	—						
S	0.09	0.28						
F (< 0.05) .	tr.	—						
$H_2O^{-105°}$ . .	0.00							
	99.62							

Quantitative System: V: 1: 2: 1: 1: 4.
Or: Ab: An — 0.00: 0.00: 100.00.
Sp. gravity $\frac{20°}{4°}$ C = 3.959.

bound water and alkalies in the eulysites (cf. new analysis No. 1 do not agree with any normal metamorphism through the accessio of hydatogeneous rest-differentiates. Even if fayalite may be forme in simple thermal metamorphism in contact auroles, this can hardl account for the present peculiar metamorphism which seems to be boun to the presence of adjoining granites unusually rich in pneumatoliti compounds, such as, for instance, those indicated by the sometime very high percentage of chlorine and fluorine-apatites, tourmalin etc.

The initial metamorphic phase is characterized by orthosilicate and only a later metamorphism produces metasilicates, the metamorphic sequence being:

No alumina present:	Alumina present:
Fayalite + quartz	Fayalite + garnet + quartz
Hyperstene + quartz	Clinopyroxene + quartz + garnet
↓ Grünerite + quartz	↓ Hornblende + quartz + chlorite

Maybe one may predicate a metamorphism under conditions characterized by very high pressure as well as by the presence of hig temperatured volatiles, mainly consisting of chlorine and reducin gents, such as hydrogen. This metamorphism must have led to the itogeneous creation of a mobile fayalite-quartz-liquid, as testified y the fayalite dykes at Gymås, to which reference has already been ade and the true character of which is that of autogeneous fissure-eins and not exogeneous dykes.

The Migmatites.

There are no definite regional zones of metamorphism within the igmatite region, the zones being locally arranged according to the ze of the xenolithes and the predominance of the granites. The hlorite-zone, for instance, is preserved only within the central parts some of the xenolithes, such as the quartz sediments at Gäddtjärn. he biotite zone is most in evidence, but a more advanced metamorhism is represented within large areas by cordierite-sillimanite-garnet nd sillimanite-andalusite-garnet-gneisses.

Every transitional stage from the leptitic biotite schists to preominatingly granitic garnet-gneisses is represented (cf. Pl. II—VI) nd the chemical composition ranges from intermediary to very acid cks, which latter may originally have been quartzitic sediments f. Analyses 11—12).

The garnet biotite schists also show a consecutive grading into rnet-biotite-cordierite-schists and microcline-cordierite-andalusite-uscovite-biotite-schists. The latter are encountered mostly within eas of large granitic percentage, or close to the younger granites herever a decline of the stress-factor at high temperature (cf. 11, p. 35) may be assumed. The increase of potash-felspar is accompanied y a decrease of biotite through conversion of the latter, as well as by a placement of garnet by cordierite.

The andalusite-bearing migmatites are also bound to the most gratic parts where the shearing stress has relaxed and, consequently, e intimately connected with the injection of the pegmatitic solutions the Mansjö or old Archæan granite. In the vicinity of Hylströmmen, r instance, the crystallized leptitic fragments with secondary felspar Augen») are very rich in sillimanite and andalusite. This sillimanite ems to be of a later generation than that of the »primary» schists, veloping much bigger crystals intergrown with the andalusite along e c-axes, the a- and b-axes being crossed, — a mineralogical feature orth noticing. The composition of the plagioclase is An$_{27}$ and the icrocline is almost absent, while a reddish-brown biotite is conspious. A retrogressive metamorphism at a relaxing stress is strongly nphasized.

Analysis Nr. 11.

Garnet-gneiss. Fetingsklacken (Ls - 25).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	80.98	134.83	Q	70.57	Quartz	69.0	qz	+444
TiO_2	0.14	0.18	Or	4.45	Garnet	15.3	si	560
P_2O_5	0.01	0.01	Ab	1.01	Sillimanite	9.5	ti	0.75
Al_2O_3	9.02	8.85	An	0.57	Biotite	4.9	al	37.0
Fe_2O_3,	1.38	0.86	C	7.85	Plagioclase		fm	58.0
FeO	4.31	6.00	Σ sal	84.45	$(Ab_{78}An_{22})$	1.3	c	1.0
MnO	0.04	0.06	Hy	12.46		100.0	alk	4.0
MgO	2.36	5.85	Mt	2.02			mg	0.43
CaO	0.13	0.23	Ilm	0.28			k	0.80
Na_2O	0.09	0.15	Σ fem	14·76			c/fm	0.01
K_2O	0.75	0.80	H_2O	0.76				
$H_2O^{+105°}$	0.76	4.22		99.97				
$H_2O^{-105°}$	0.26							
	100.23							

Quantitative System: II: 1: 2: 2 —.
Or: Ab: An — 73.79: 16.75: 9.46.
Sp. gravity $\frac{20°}{4°}$ C = 2.685.

Analysis Nr. 12.

Garnet-Sillimanite-Gneiss. Fetingsklacken Hill. (Ls - 567)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	72.35	120.46	Q	50.99	Quartz	53.2	qz	+229
TiO_2	0.21	0.26	Or	10.62	Garnet	20.0	si	365
P_2O_5	0.02	0.01	Ab	5.71	Biotite	12.2	ti	0.84
Al_2O_3	10.61	10.41	An	1.11	Sillimanite	7.7	al	31.5
Fe_2O_3	1.33	0.83	C	7.14	Plagioclase		fm	58.5
FeO	8.59	11.96	Σ sal	75.57	$(Ab_{85}An_{15})$	6.9	c	1.0
MnO	0.66	0.93	Hy	20.58		100.0	alk	9.0
MgO	2.00	4.96	Mt	1.91			mg	0.26
CaO	0.22	0.39	Ilm	0.43			k	0.65
Na_2O	0.65	1.05	Σ fem	22.92			c/fm	0.02
K_2O	1.88	1.94	H_2O	1.07				
$H_2O^{+105°}$	1.07	5.94		99.56				
	99.56							
$H_2O^{-105°}$	0.32							
	99.88							

Quantitative System: II: 2: 1: 2 — not represented.
Or: Ab: An — 60.89: 32:74: 6.37.
Sp. gravity $\frac{16°}{4°}$ C = 2.889.

W. of Voxna at Selmaberget and at Enfotaberget a gneiss-granit is predominant, containing only a small amount of recognisable leptiti material but being conspicuous by its andalusite and sillimanit content together with some biotite, muscovite and large greenis seudomorphs of cordierite (Pl. XIV, XV.). Where the sillimanite ntersects joints of microcline and cordierite, they are marginally onverted into a reddish-brown biotite.

In this connection a few words may be said about the metamor-hism of the cordierites, which, within the migmatites and contaminated neiss-granites respectively, show a somewhat different character. n the former rocks the metamorphism generally takes the usual form f pinitic, finally laminar, muscovite-alteration, starting from the leavages or partings, whilst in the latter rocks the praseolitic chlorite-lteration is the common feature. In some gneiss-granites, however, n almost isotropic yellowish-greenish substance is formed, sometimes ntergrown with green biotite or, in exceptional cases, with antophyllitic mphiboles (cf. Pl. XV), this alteration product being of distinctly ositive optical sign and having an axial angle of a few degrees only.

Sometimes the metamorphic product is less isotropic and of a more ure yellow-brownish colour, the optical sign being negative and the xial angle 10°—15°. Both optically positive and negative cordierite ccurring within the migmatites, the sign of the alteration product is, enerally, but not always, the reverse of the fresh mineral. Even the trongest magnification fails to reveal any flakes of chlorite, the weak olarisation, consequently, probably being of aggregative character.

At the contact towards the Rätan granite on the S.E. shore of Lake Dåasen the cordierite-sillimanite-gneiss is very rich in muscovite, vhile andalusite and biotite are wanting. The muscovite, which is ighly poeciloblastic, certainly owes its presence to pneumatolitic nfluence from the granite. The cordierite encloses an unusually large mount of zircon crystals surrounded by pleochroic haloes, colourless n sections $\parallel \gamma$ and yellow $\parallel \alpha$. The same yellow haloes occur within he muscovite, and the pleochroism, although much stronger, coincides vith that of the mica which is faint. One point of interest is the very narked decrease of birefringence within the halos.

The same type of metamorphism is also encountered where the nigmatites border on the younger Risberg-granite, the accession f potash in the shape of muscovite being strikingly conspicuous.

The Oldest Granite, the Mansjö Granite and the Palingenesis.

The oldest archæan granites occupy mainly the S.E. and central part of the region E. of the Oreälv. They are microcline granites of partly somewhat porphyric, partly more even-grained texture, their plagioclase ranging from An_{15} to An_{25}. The femic constituents are mostly lepidolitic biotite, some green hornblende and some secondary chlorite. They closely resemble the more acid types of the Ljusne gneiss-granite on the E. coast, and reference may be made to the description of this granite already published by the author. (G. F. F. Vol. 50, pp. 321—327.)

In the southern parts, the gneiss-granite is better preserved than in the ridge between Voxnaälv and Sandsjö River, where it has been subjected to strong dynamic pressure. From Björkberg past Hamra up to the Voxna River W. of Voxna Hed, it is very schistose but of uniform composition, except a few enclosures of ore-bearing leptites, such as at Kivanhoberget. The big black biotite flakes give it an almost banded appearance. The best preserved part of the oldest granite is found at Hylströmmen, where the brecciation of the leptitic schists is nicely exposed at the rapids.

The small leptite areas are relics of the brecciation of the earlier earth crust, thermally strongly metamorphosed, but only slightly injected by pegmatites, or else migmatitized.

There is a striking difference in the behaviour of the old pink granite of Group I and the succeeding gray Mansjö granite of Group II. This latter intensively brecciates and absorbs the older rocks, leptites as well as granites, and is responsible for the origination of the migmatites. A description of the Mansjö granite is given in the Mansjö-memoir, but two new analyses, Nos. 13 and 14, have been added, permitting of a better account of the chemistry and range of its composition.

Of these two, the analysis from Svensbo represents a rather contaminated granite which, although megascopically homogeneous, has absorbed and digested a fair amount of argillaceous leptitic sediments, almandite and sillimanite being present in the mode. The second analysis differs conspicuously from the typically potassic Mansjö granite, as described from Mansjö, soda and potash balancing each other. In this case, however, the contamination is not very evident and the rock may be an almost normal differentiation member of a granitic magma-suite or a totally regenerated palingenetic rock.

That is to say, the question is, if we may really speak of a definite Mansjö-magma. As a uniform granite, it occurs only within very small areas, Mansjö and Räkarsvedjan being the two largest. At the latter place it is, megascopically, completely granitic and the gneissose protoclastic features are revealed by the microscope alone.

At the localities mentioned it is strikingly similar to the gray potassic medium-grained Stockholm granite, although it is probably slightly more sodic.

Outside these uniform areas, the Mansjö granite is found as the

Analysis Nr. 13.

Mansjö gneiss-granite 200 m. North of Svensbo. (Svbo I.)

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	74.19	123.52	Q . . . 39.78	Quartz . . . 39.8	qz +213	s 81
TiO_2	0.12	0.15	Or . . 35.60	Microcline . . 32.5	si 429	A 5.6
P_2O_5	0.13	0.09	Ab . . 10.98	Plagioclase	ti 0.52	C 3.8
Al_2O_3	14.70	14.42	An . . 2.23	($Ab_{80}An_{20}$. 10.6	al 55.0	F 4.0
Fe_2O_3	0.05	0.03	C . . . 5.20	Lefidomelan . 5.8	fm 17.0	a 12.5
FeO	2.05	2.85	Σ sal . 93.79	Muscovite . . 5.2	c 4.0	c 8.5
MnO	0.03	0.04	Hy . . 5.53	Almandite . . 2.2	alk 29.0	f 9.0
MgO	0.80	1.98	Il . . . 0.26	Sillimanite . 2.7	mg 0.41	n 2.5
CaO	0.62	1.10	Ap . . 0.26	Zircone, Ores	k 0.76	k 1.79
Na_2O	1.27	2.05	Σ fem . 6.05	Apatite . 1.2	c/fm 0.22	
K_2O	6.02	6.39	H_2O . . 0.15	100.0		
$H_3O^{+105°}$	0.15	0.64				
			99.99			
$H_2O^{-105°}$	0.10					
	100.23					

Quantitative System: I: 3: 1: 2 — *Magdeburgose.*
Osann's Type: No corresponding type.
Or: Ab: An — 72.93: 22.49: 4.58.
Sp. gravity $\frac{20°}{4°}$ C=2.621.

Analysis Nr. 14.

Mansjö Gneiss-Granite (Ls—11) from the well at Nyby.

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	74.27	123.66	Q . . 31.35	Quartz . . . 33.7	qz +167	s 80
TiO_2	0.10	0.13	Or . . 28.35	Plagioclase	si 403	A 6.8
P_2O_5	0.17	0.12	Ab . . 28.30	($Ab_{91}An_9$) . 31.6	ti 0.33	C 1.6
Al_2O_3	13.16	12.91	An . . 4.44	Microcline . 24.7	al 42	F 3.4
Fe_2O_3	0.00	—	C . . 0.81	Biotite . . . 9.4	fm 18	a 17.0
FeO	1.92	2.67	Σ sal . 93.25	Titanite . . . 0.4	c 6	c 4.5
MnO	0.01	0.01	Hy . 6.05	Apatite . . . 0.2	alk 34	f 8.5
MgO	1.10	2.73	Ilm . 0.17	100.0	mg 0.50	n 5.1
CaO	1.04	1.86	Ap . . 0 34		k 0.48	k 1.69
Na_2O	3.34	5.39	Σ fem 6.56		c/lm 0.35	
K_2O	4.77	5.06	H_2O . 0.26			
$H_2O^{+105°}$	0.26	1.44				
			100.07			
$H_2O^{-105°}$	0.06					
	100.20					

Quantitative System: I: 4: 2: 3 — *Toscanose.*
Osann's Type: No. 12. Alby (s 79, a 17.5, c 3.5, f 9.0, n 4.4, k 1.62).
Or: Ab: An — 46.41: 46.33: 7.26.
Sp. gravity $\frac{20°}{4°}$ C=2.613.

brecciating pegmatitizing and migmatitizing medium of the older rocks only. It displays all stages of contamination, and any number of inclusions in varying degrees of digestion, from »spectral shadows» to still recognisable sediments. Actually, the region of the Mansjö granite constitutes an area of intense thermo-chemical breaking down of the older rocks, on such a large scale and in such varying forms, that it can hardly be explained simply as the result of the intrusion by a large underlying magma of specified composition. In such a case one would expect this magma to occur in larger masses somewhere at least within the region.

The author considers this region to be, instead, a typical case of a regional subsidence of the earth crust and a palingenetic remelting of its base when sunk to the required depth and thermal level. The conception of the earth's crust having two surfaces, a lower one — generally too much overlooked when interpreting the present two-dimensional erosion section — as well as an upper one, and the geological consequence of the component parts of the crust moving in magmatic-sedimentary-magmatic cycles, has lately been generally accepted by Fennoscandian geologists. In this case it is the only reasonable one to apply in order to explain the granitization-area.

On the subsidence, the bottom parts of the leptite sediments as well as older granites have been brought to levels where refusion took place and a palingenetic magma was gradually formed. The tectonic movements of subsidence must, of course, — as evidenced by the affected areas — have been on a very large scale and, consequently, innumerable zones of weakness are likely to have arisen within the sinking supercrustal blocks.

One gets the impression that the subsiding action itself has, so to say, forced the regenerated magma through those zones of weakness before any great accumulation of molten magma was formed, and continued doing so at a rate approximately corresponding to the melting rate of the subsiding base.

In an recent paper (37), WEGMANN has given an exposé of the anatexis and the magmatic cycles, which coincides with the view held by Fennoscandian geologists during the last few years and, in Sweden, is especially emphasized by MAGNUSSON. WEGMANN seems, however, (cf. Fig. 9 of his paper) to assume large masses of molten magma underneath the earth crust as imperative for the initiation of the migmatisation process, regarding the solid crust as a comparatively thin shell floating on magma. It is, to be sure, axiomatic that, in those ancient days, the central heat of the earth was higher and the magmatic liquids rose nearer to the surface, but, nevertheless, I doubt whether his schematical diagram is applicable to the Swedish palingenetic areas of the Mansjö and Stockholm type. The latter granite, for instance, on the maps generally given as a real granite area, is, practically speaking, only a big swarm or breccia of palingenetic dykes and a district of migmatites and granites of every degree of contamination.

The uniformally high percentage of volatiles always accompanying the granites of the Stockholm type is also very suggestive. The volatiles are actually those parts of the rocks which one would expect to be the first set free on the basal heating of the supercrustal rocks, especially at a sudden relaxation of pressure. Such relaxation may be caused by different agencies, as for instance by lateral displacement of blocks, by supercrustal zones of weakness penetrating to palingenetic depths etc. A natural consequence of an initial concentration of volatiles would be an accelerated activation of the other molecules of the sinking rocks too, and, at the same time, an increased internal pressure constituting a tendency to early intrusions into higher levels before any large masses of palingenetic magma were formed. WEGMANN reasons on different lines. He assumes the volatiles of the migmatites to be derived from deep-seated magmas, having been absorbed by sediments or greenstones poor in alkalies on the ascension of the migmatite-front. He emphasizes the removal of the alkalies and halogenes by erosion, and the »pumping up» of new supplies from the interior of the earth by the migmatitization process. He even launches a new theory of the origin of the alkali rocks, conceiving them to be magmas, which on their »migmatitic advance» have not struck any alkali-absorbing supercrustal rocks.

This is not the place to enter into a discussion of the pros and cons of this hypothesis, especially as I shall return to the subject in a coming paper on the alkaline area of Alnö. I only wish to point out in this connection, that the erosion-conditions ruling at the dawn of geological times can hardly be judged by comparison with those prevailing to-day. There is no evidence of the leptitic sediments having been poor in alkalies, especially as the leptitic areas of Central Sweden are conspicuously free from quartzitic sediments, even in their best preserved part, and those of Northern Sweden are secondarily silicified. Most of those sediments were, originally, protoclastic, and, as shown by the analyses of this memoir, in the case of more recent epochs, such tuffitic sediments contain a fair percentage of alkalies as well as fluorine. If the leptitic volcanic acid effusives were anything like the Loos- and Noppi-quartz porphyries, they would have been very rich in potash. GOLDSCHMIDT has pointed out the customary presence of boron in recent sediments, and the unusually common occurrence of tourmaline in the granites of Group II is also certainly suggestive (cf. the Härnö granite (3. fig. 43)).

Consequently, I conceive the initial mobilisation of the volatile phases at the base of the subsiding leptite blocks of this region as autogeneous, — although theoretically there is nothing to prevent an activation and volatile concentration of underlying rocks too.

In the case of the Mansjö, Stockholm, and Härnö granites, I suggest, however, that this participation of underlying magmas must have been very slight or even nonexistent, as such a magmatic contribution must presuppose one and the same magma underlying the whole area, as, otherwise the three granites could not very well be of such uniform habit.

The activation of the volatiles of the subsiding blocks may be conceived as having started at a level above permanently magmatic depths. Once started, the process would continue, more rock going into solution and the subsidence continuing until checked by the descending »coolingfront». The palingenetic level would constitute a fluid or plastic layer, occasioning lateral and differential movement registered on the surface as mountain-folding or faulting.

Actually, WEGMANN's theory leads to the production of a contaminated magma, while the present author's conception is that of a truly palingenetic one.

Consequently, the present author accepts the palingenetic hypothesis, as such, as an explanation of the Mansjö migmatites and granite, and he admits the subsidence of the leptites to palingenetic depths, but he considers the real palingenetic process in this case to have been restricted to a fairly narrow zone at the base of the subsidence. This zone may, in those days, not even have been a very deep seated one.

To this theory of mine the objection may be raised, that on account of their field relations and their general tectonic behaviour, the large uniform granite areas of the Revsund granite in the N. and the scattered but numerous smaller occurrences of Fellingsbro granite in Central Sweden too, are considered as palingenetic and contemporaneous with the Stockholm granite. To this the answer will be that locally, of course, the re-melting may have advanced farther, and the underlying rocks may also have been mobilised, or underlying magmas may even have risen to the palingenetic level. Even if this magma may, to some extent, be contaminated and contain a certain amount of volatiles giving them a definite pegmatitizing character, nevertheless they are not true palingenetic magmas of the Stockholm-Mansjö type. As already inferred, the palingenesis is not necessarily to be assumed as connected with any large subjacent magma body, even if such a body may have existed locally in consequence of varying geoterms.

Against an assumption of the Mansjö and Stockholm granites simply representing a higher erosion level of the palingenetic zone, there speaks the absence of any large areas of the same type of granite anywhere. Neither the Revsund, nor the finnish Hangö-granite are petrologically the same granite. Where the base of the palingenesis has been exposed, which may be the case within the Revsund district, if it really belongs to the Svecofennidian orogenesis, we actually encounter a rock which, when uncontaminated, is older than and, when contaminated, contemporaneous with, or even younger than, the true palingenetic granites.

What I wish to accentuate is the existence of this magma prior to the migmatitization, which does not, of course, preclude its later intrusion of the migmatite block and its apparently younger record on the present erosion section.

This point has been emphasized, as there has been a tendency to classify all the granites of Group II as palingenetic which, according to the present author's opinion, is not always the case, even if they are contemporaneous and co-operative with the generation of the true palingenetic magmas.

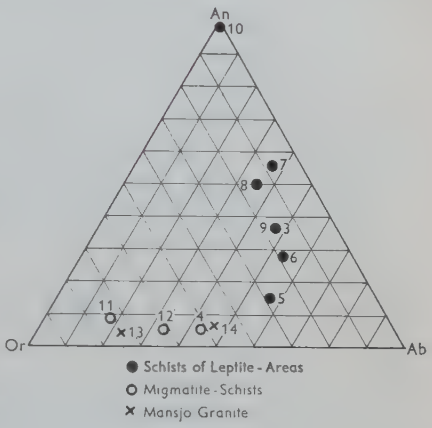


Fig. 6.

Finally, a few words may be said about the chemical influence of the Mansjö granite on the leptitic schists during the process of migmatitization. Within the appended diagram, fig. 6, there have been entered the Or-Ab-An ratios of the norm of the schists as well as the granites. The diagram clearly shows how the chemical composition of the migmatitizing agents and the schists gradually merge as the migmatitization process proceeds, the reference values of the garnet-biotite-schists being practically identical with those of the granite. On the other hand, the larger the remaining xenolithic leptitic areas are, and the better, consequently, the primary features are preserved, the more do their ratios differ from those of the granites. The extreme case is represented by the eulysites of Mansjö.

The Old Greenstones.

Reference has already been made to the amphibolites within the migmatite area as being undoubtedly older than the migmatitization process. A more doubtful position is occupied by the greenstone area of Loberget, E. of Loobonäs, the rocks being represented by the analyses Nos. 17 and 18.

In my preliminary report it was considered to belong to the Loos-greenstones, but a continued study of sections as well as new analyses have called for a revisal of the previous classification. Unfortunately, the field evidences are not very clear, the greenstones being, it is true, cut on the N.W. slope of the hill by an aplitic dyke of Risberg granite, but also by pegmatite of rather undeterminable age, which may be offshoots of the Mansjö granite. The uralitisation of the greenstone, however, indicates a thermal influence of larger and more regional character than that which can be attributed to the Risberg dyke. The mineral alteration of the rock is also quite different to that of the Loos greenstone, but, on the other hand, a remarkably well-preserved primary texture, quite comparable with the Loos rocks, prevails within its central part.

The pyroxene in those gabbroid, slightly metamorphosed, rocks is a diopsidic, faintly greenish augite of $2V_{550} = 54°$; $c/_{\gamma} = 45.5°$; $(\gamma - \alpha)_{550} = 0.022$; $n_{\beta\,550} = 1.715$; marginally converted into green hornblende. The plagioclase is a labradorite, An_{63}, and the potash evidently enters the plagioclase, as no biotite or orthoclase is present. This is illustrated by analysis No. 17.

The marginal parts of the greenstone are all converted into an amphibolite of considerably more acid plagioclase, An_{33}; all the pyroxene having been transformed into hornblende and some biotite entering the composition. These changes indicate a strong contact influence of adjoining acid magma hardly referable to any other granite than the Mansjö and, consequently, denoting an age contemporaneous with the amphibolites of the migmatite area. The primary mineralogical features of the central part, are, however, puzzling. The Loberget Hill not having been subjected to a very thorough survey, the presence of unexamined exposures of decisive influence on the age determination is not precluded, and all that may be stated with certainty to-day is the totally different character of the rocks when compared with the Loos greenstones.

If the pegmatite dykes should prove to belong to the Risberg granite, an age older than the Loos-eruptives but younger than the migmatitization process may also be possible and even most probable. Such basic

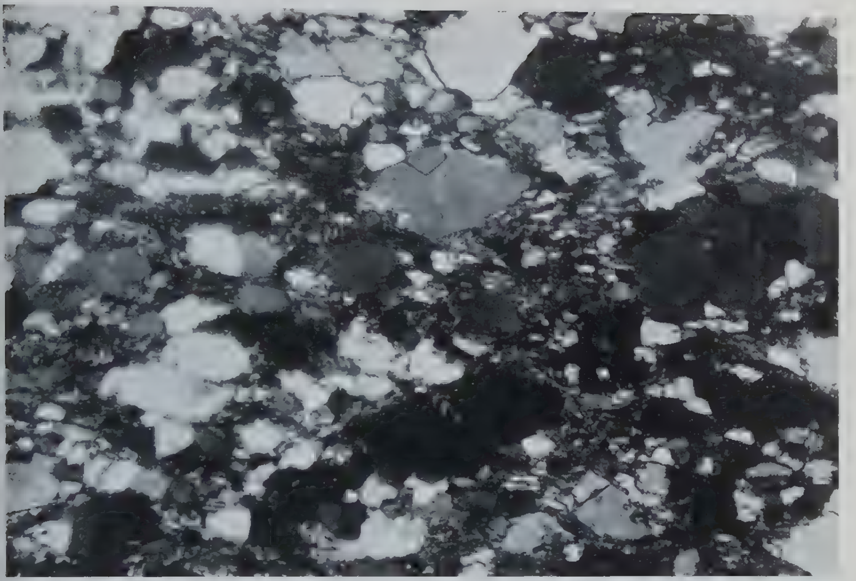


Fig. 1. Upper Loos quartzite at thrust fault south of Rullbo at Woxna Älv. Nic. +. Magnif. × 55.

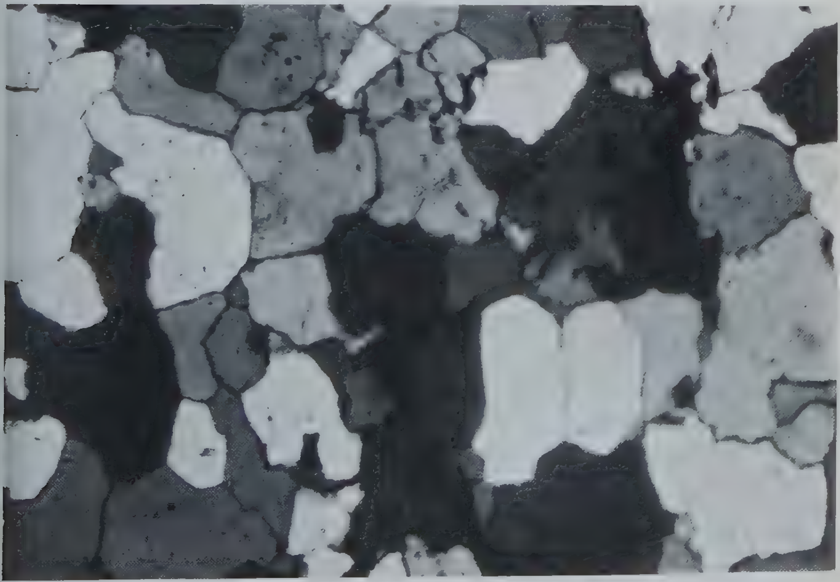
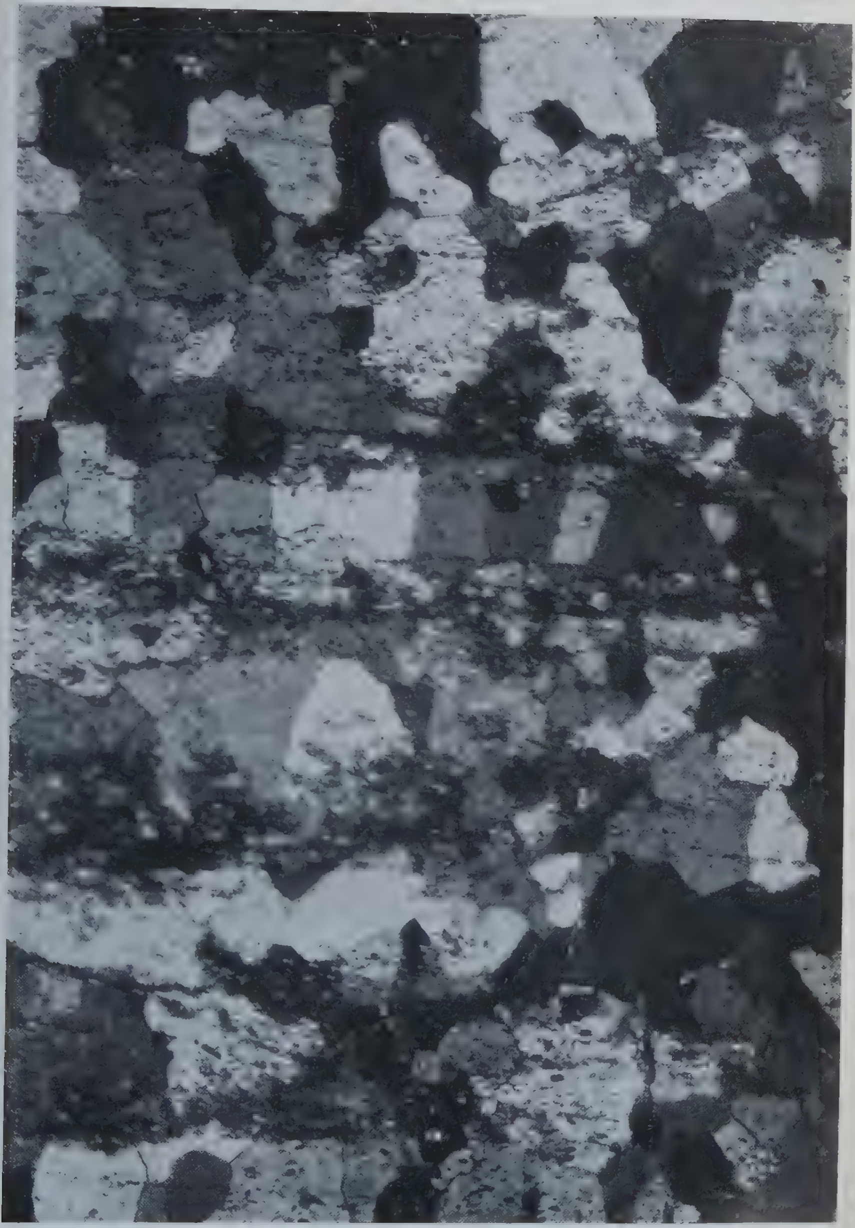


Fig. 2. Quartzite-pebble in conglomerate overlying quartzite of Fig. 1. Nic. +. Magnif. × 55.

Biotite-banded quartzite at Fetingsberget, re-crystallized by the thermal action of the Dåasen granite. The quartz is optically almost homogeneous. Nic. +. Magnif. × 55.



Sub-Loosian quartzite at Storkvarnberget, completely re-crystallized by the thermal action of the greenstone. Small diopside-grains indicate the original sedimentation. Nic. +. Magnif. × 55.

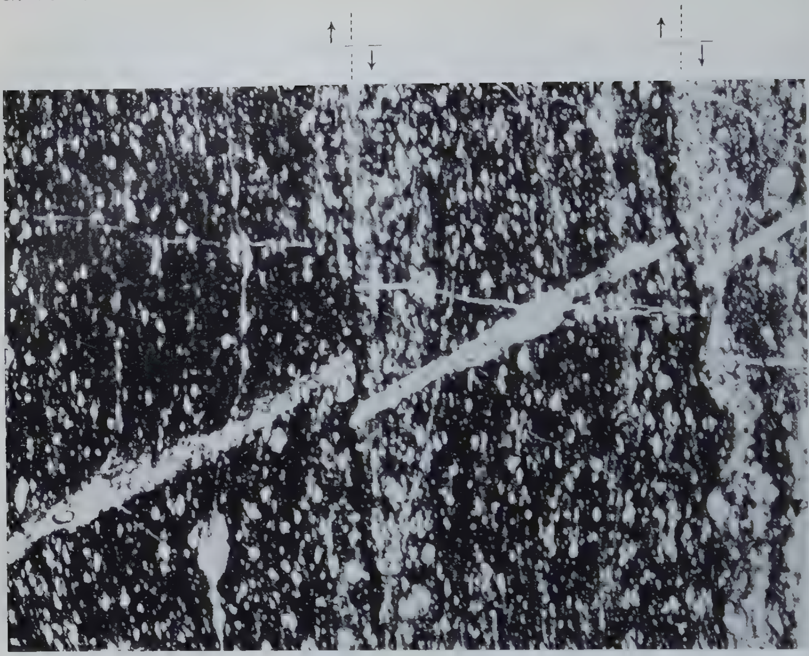
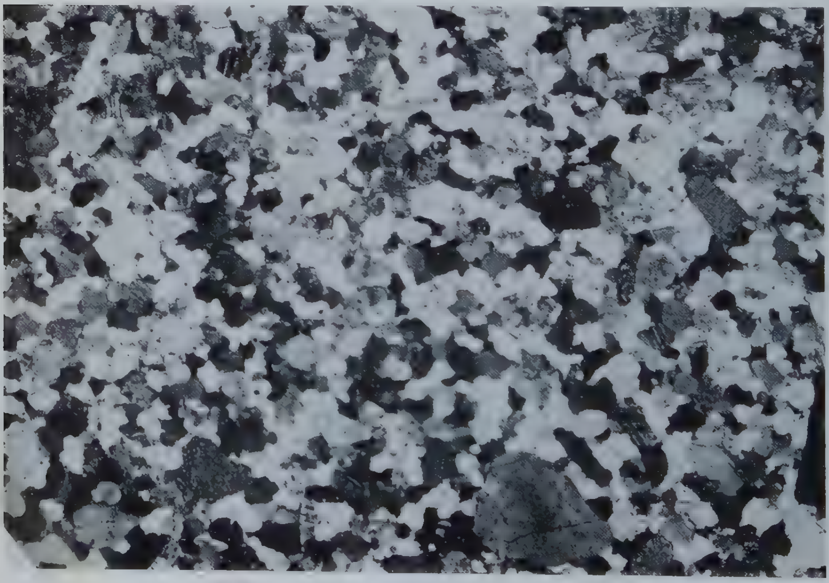


Fig. 1. Graphite-bearing quartzite at Rullbo copper mines, N of Rullbo. Arrows indicate two small thrusts parallel to the stratification. Ord. light. Magnif. × 10.



. Quartzitic base of conglomerate W of Karlsberg, S of Loos. Basal conglomerate of the upper Loos Series. Nic. +. Magnif. × 10.

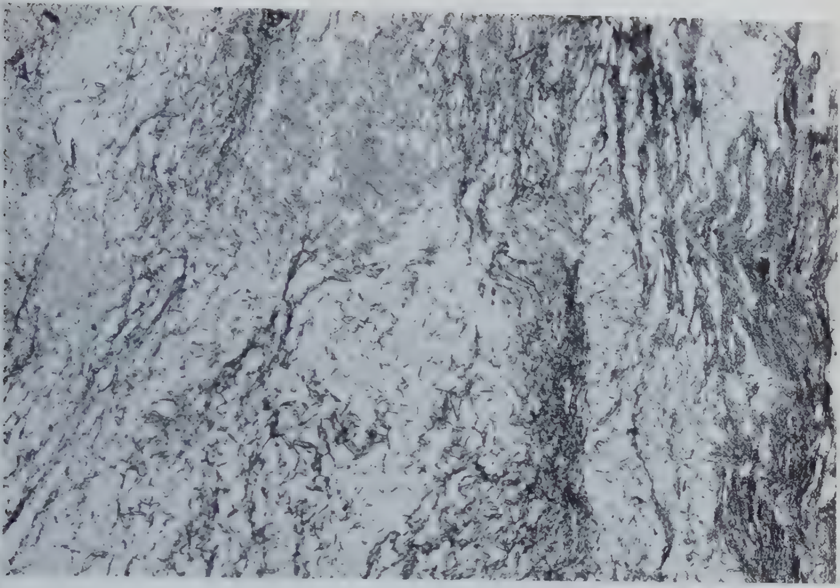


Fig. 1. Biotite-sericite-schists from Ställstensberget E of Tenskog. Dark gray is biotite, light gray is sericite, white is quartz. Ord. light. Magnif. × 10.

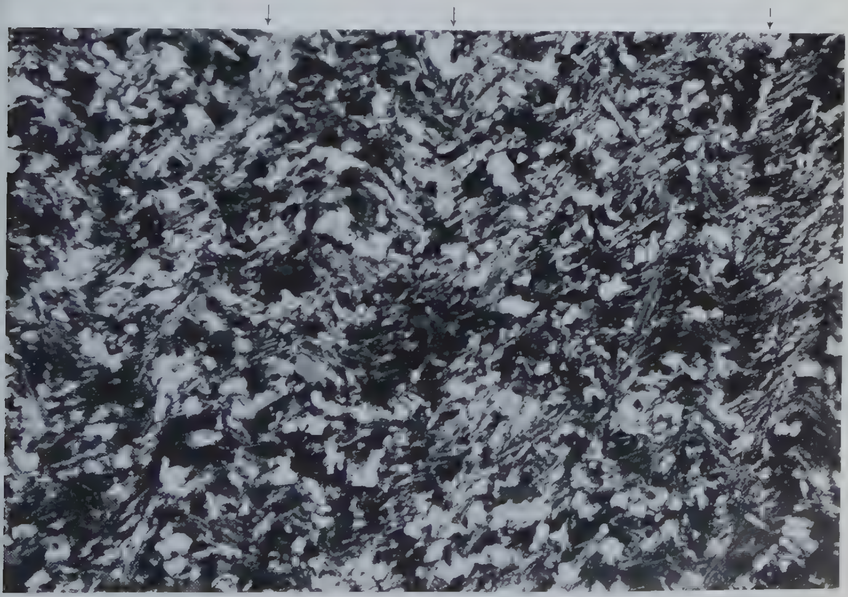
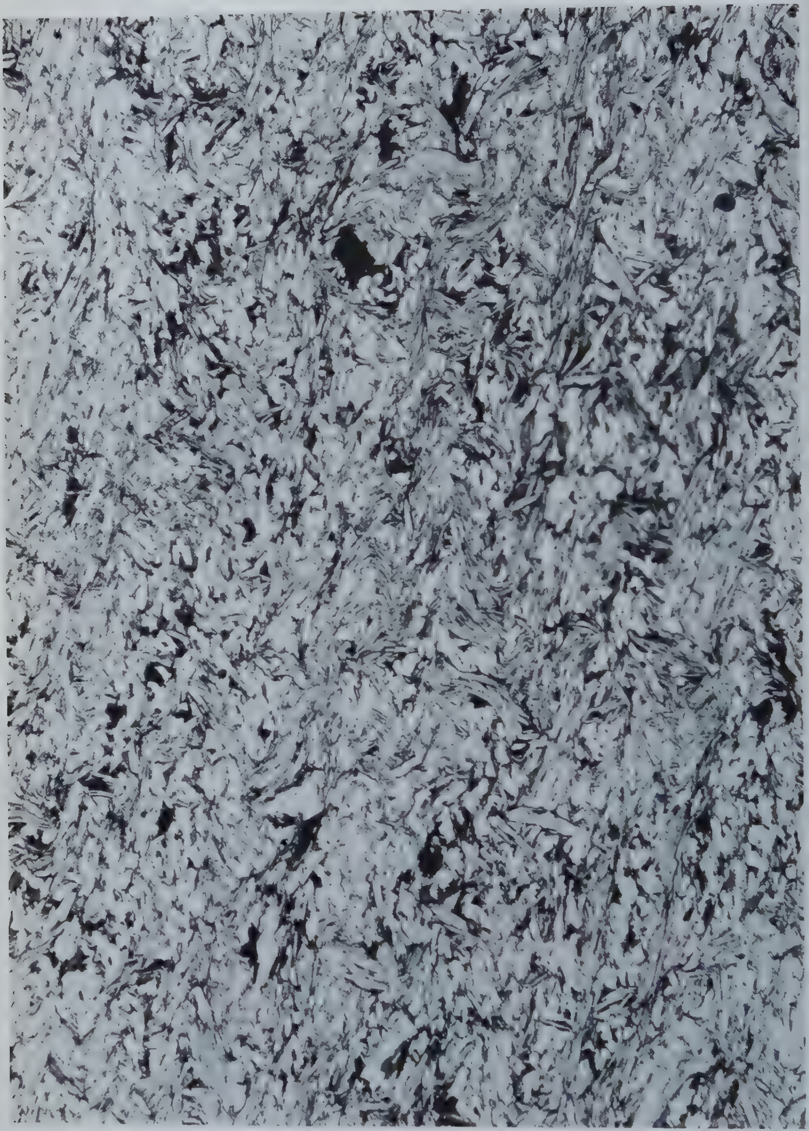
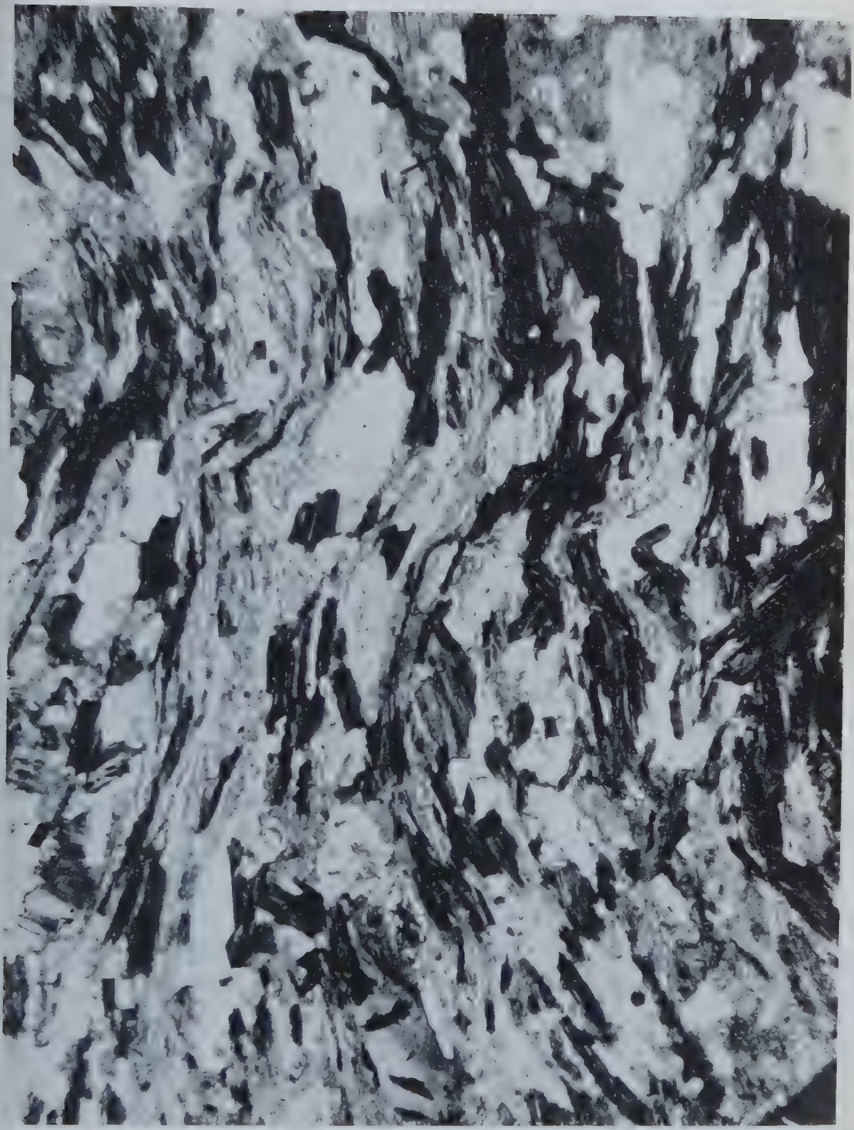


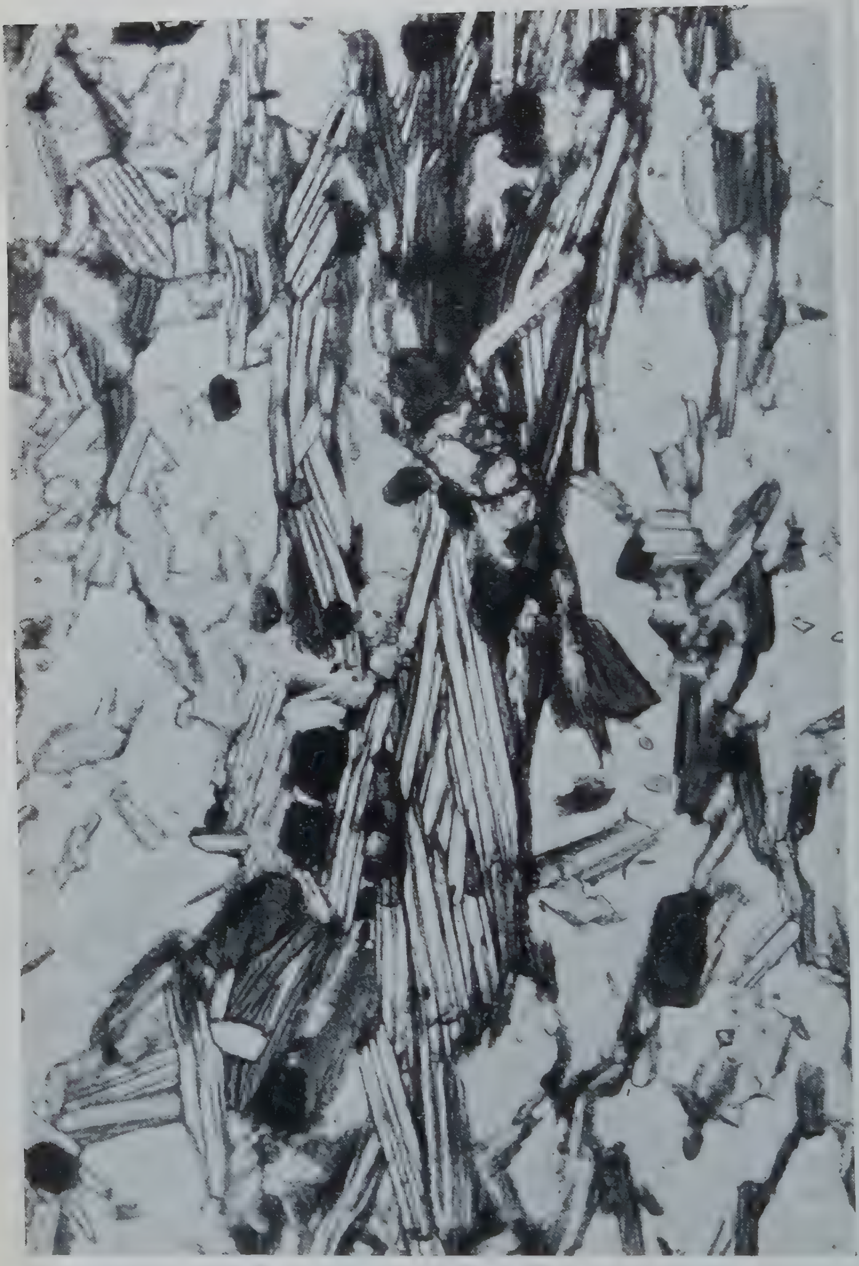
Fig. 2. Plicated Sub-Loosian mica-schist N of Woxna Hed. Arrows indicate secondary schistosity transverse to the original bedding. Nic. +. Magnif. × 20.



Plicated chlorite-muscovite-schist from Ställstensberget. Light-gray is chlorite, white is muscovite, black is biotite or ores. Ord. light. Magnif. × 55.



Sub-Loosian chlorite-biotite-schist from Fetingsberg cottage. Both the biotite and chlorite are green. By the use of colour-filters during exposure the biotite has been made to appear dark-gray and black, and the chlorite light-gray. Ord. light. Magnif. × 40.



Sub-Loosian biotite-sericite-schist one km W of Åsen, Loos. The roughly rectangular dark-gray grains are tourmaline. Ord. light. Magnif. × 55.

Analysis Nr. 15.

Gabbro-dyke, Svensbo. Centre of dyke.

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	41.07	68.41	Or . .	5.39	Hornblende .	66.1	qz	— 42	s	41.1
TiO_2	0.25	0.31	Ab . .	2.62	Olivine	22.1	si	70	A	1.9
P_2O_5	0.17	0.12	An . .	15.86	Calcite . . .	4.2	ti	0.37	C	3.4
Al_2O_3	8.96	8.77	Ne . .	5.09	Biotite . . .	2.1	al	9.0	F	48.3
Fe_2O_3	3.08	1.93	Σ sal .	28.96	Apatite . . .	0.4	fm	70.5	a	1.0
FeO	6.28	8.74	Di . .	15.81	Serpentine and ores . . .	8.6	c	17.5	c	2.0
MnO	0.31	0.44	Ob . .	43.36			alk	3.0	f	27.0
MgO	24.32	60.32	Mt . .	5.04		100.0	mg	0.86	n	7.4
CaO	9.76	17.40	Ilm .	0.46			k	0.29	k	0.82
Na_2O	1.41	2.27	Ap . .	0.34			c/fm	0.25		
K_2O	0.74	0.79	Cc . .	4.20			co_2	4.90		
$H_2O +110°$	1.91	10.60	Σ fem	69.21						
CO_2	1.84	4.18	H_2O .	1.91						
				100.08						
	100.10									
$H_2O -110°$	0.06									
	100.16									

Quantitative System: IV, 1: 1: 1: 2 — No name.
Osann's Type: No. 95. Yamaska (s 45, a 1, c 2, f 27, n 7.6, k 0.73) or No. 102. Kaltes Tal (s 41, a 1.5, c 1, f 27.5, n 5.2, k 0.60).
Or: Ab: An: Ne — 18.61: 9.03: 54.78: 17.58.
Sp. gravity $^{16°}_{4°}$ C = 3.029.

Analysis Nr. 16.

Gabbro-dyke, close to contact. Svensbo.

Analyst N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	42.29	70.44	Or . .	4.46	Hornblende .	68.9	qz	— 48.5	s	42.4
TiO_2	0.60	0.75	Ab . .	2.61	Pyroxene . .	16.0	si	70.5	A	2.6
P_2O_5	0.32	0.22	An . .	14.71	Anorthite . .	0.6	ti	0.80	C	3.1
Al_2O_3	9.69	9.51	Ne . .	8.54	Calcite . . .	4.0	al	9.5	F	46.3
Fe_2O_3	2.07	1.30	Σ sal .	30.32	Biotite . . .	1.1	fm	66.0	a	1.0
FeO	6.41	8.92	Di . .	22.65	Apatite . . .	0.8	c	20.0	c	2.0
MnO	0.16	0.23	Ol . .	37.37	Serpentine and ores	8.6	alk	4,5	f	27.0
MgO	21.82	54.12	Mt . .	3.00		100.0	mg	0.82	n	8.1
CaO	11.39	20.31	Ilm .	1.16			k	0.19	k	0.62
Na_2O	2.10	3.39	Py . .	0.26			c/fm	0.31		
K_2O	0.77	0.82	Ap . .	0.70			co_2	4.00		
$H_2O+110°$	0.79	4.38	Cc . .	3.98						
CO_2	1.75	3.98	Σ fem	69.12						
S	0.12	0.37	H_2O .	0.79						
				100.23						
	100.28									
$H_2O-110°$										

Quantitative System: IV, 1: 1: 2: 1 — No name.
Osann's Type: No. 95. Yamaska (s 45, a 1, c 2, f 27, n 7.6, k 0.73),
Or: Ab: An: Ne: 14.71: 8.61: 48.51: 28.17.
Sp. gravity $^{16°}_{4°}$ C = 3.015.

Analysis Nr. 17.

Greenstone from southern part of Loberget (Ls - 6).

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	49.60	82.58	Q . . . 0.12	Felspar	qz − 10	s 50.8
TiO_2	0.65	0.81	Or . . 2.81	($Ab_{37}An_{63}$) . 37.0	si 104	A 1.7
P_2O_5	0.21	0.15	Ab . . 12.05	Augite and	ti 1.00	C 4.9
Al_2O_3	10.96	10.72	An . . 21.97	Hornblende 55.6	al 13.5	F 35.9
Fe_2O_3	3.82	2.39	Σ sal . 36.95	Ores 6.8	fm 55.5	a 1.0
FeO	7.57	10.54	Di . . 30.14	Apatite . . . 0.6	c 27.5	c 3.5
MnO	0.30	0.42	Hy . . 24.43	100.0	alk 3.5	f 25.5
MgO	11.51	28.55	Mt . . 5.55		mg 0.64	n 8.2
CaO	12.42	22.14	Ilm . . 1.23		k 0.18	k 0.90
Na_2O	1.42	2.29	Ap . . 0.60		c/fm 0.50	
K_2O	0.50	0.53	Σ fem . 61.95			
$H_2O+105°$	0.95	5.27	H_2O . . 0 95			
			99.85			
	99.91					
$H_2O-105°$	0.06					
	99.97					

Quantitative System: IV: 5: 4: 4 — No name.
III: 5: 4: 4 — *Auvergnose.*

Osann's Type: No. 77. Emerald Mine (s 50, a 2, c 3.5, f 24.5, n 8.0, k 0.83)

Or: Ab: An — 7.65: 32.70: 59.65.

Sp. gravity $\frac{20°}{4°}$ C: 3.048.

Analysis Nr. 18.

Amphibolite, Loberg Mt. (Ls - 7.)

Analyst: J. Petrén and H. v. Eckermann.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	49.80	82.92	Or . . 6.71	Plagioclase	qz − 25	s 54.5
TiO_2	1.08	1.35	Ab . . 29.89	($Ab_{67}An_{33}$) . 51.9	si 115	A 4.5
P_2O_5	0.25	0.18	An . . 22.81	Hornblende	ti 1.95	C 5.2
Al_2O_3	15.36	15.07	Σ sal . 59.41	and some bio-	al 21.0	F 26.2
Fe_2O_3	2.57	1.61	Di . . 8.88	tite 43.7	fm 51.0	a 4.0
FeO	9.51	13.24	Hy . . 9.76	Ores 3.8	c 18.0	c 4.5
MnO	0.30	0.42	Ol . . 14.00	Apatite . . . 0.6	alk 10.0	f 21.5
MgO	7.72	19.15	Mt . . 3.72	100.0	mg 0.53	n 7.1
CaO	7.18	12.80	Ilm . . 2.09		k 0.17	k 0.85
Na_2O	3.54	5·71	Ap . . 0.64		c/fm 0.36	
K_2O	1.16	1.23	Σ fem . 39.09			
$H_2O+105°$	1.39	7.72	H_2O . . 1.39			
			99.89			
$H_2O-105°$	0.10					
	99.96					

Quantitative System: II: 5: 3: 4 — *Andose.*

Osann's Type: No. 92. Kinnekulle (s 53.5, a 3.5, c 5.5, f 21.0, n 8.0, k 0.86).

Or: Ab: An — 11.30: 50.31: 38:39.

Sp. gravity $\frac{20°}{4°}$ C = 2.967.

Analysis Nr. 19.

Diabase from Hagermansdalen. (Wx-258.)

Analyst: J. Petrén and H. v. Eckermann.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	49.36	82.19	Or . 9.48	Plagioclase	qz − 23	s 55
TiO_2	1.18	1.48	Ab . 30.90	($Ab_{48}An_{52}$) . 53.2	si 121	A 5.0
P_2O_5	0.23	0.16	An . 29.76	Hornblende(and	ti 2.21	C 7.0
Al_2O_3	18.60	18.25	Σ sal . 70.14	some augite) 28.4	al 27.0	F 21.1
Fe_2O_3	0.80	0.50	Di . . 2.53	Biotite . . . 14.4	fm 44.0	a 4.5
FeO	10.80	15.03	Ol . . 22.50	Ores 3.5	c 18.0	c 6.5
MnO	0.26	0.37	Mt . 1.16	Apatite . . . 0.5	alk 11.0	f 19.0
MgO	5.65	14.01	Ilm . 2.26	100.0	mg 0.46	n 7.8
CaO	7.02	12.52	Ap . 0.62		k 0.23	k 0.84
Na_2O	3.63	5.86	Σ fem 29.07		c/fm 0.41	
K_2O	1.63	1.73	H_2O . 0.88			
$H_2O+110°$	0.88	4.89	100.09			
V_2O_5 (<0.02%)	tr	—				
Cr_2O_3	0.00	—				
S	0.010	0.03				
F (<0.05%)	tr	—				
$H_2O-110°$	0.10					
	100.15					

Quantitative System: II: 4: 3: 4 — *Tonalose.*

Osann's Type: No. 91. Serrado (s 55.5, a 5.5, c 5.5, f 19, n 7.1, k 0.82).

Or: Ab: An — 13.52: 44.05: 42.43.

Sp. gravity $\frac{20°}{4°}$ C = 2.879.

rocks do exist elsewhere within the area represented by the olivine-gabbro dykes of Svensbo, which intersect the migmatites, and by the diabase dykes of Mansjö and the E. side of Loberget.

A full account of the gabbro has been given in the author's previous paper on the graphite deposits of S. Svensbo (4.), and the two analyses Nos. 15 and 16 are reprinted from that paper, their norms being added and the specific gravity. The presence of a large percentage of nephelite and olivine in the norms is in striking contrast to any other greenstone within the region. Actually, the rocks, chemically, are not very far removed from the doleritic diabases, even if they are unquestionably much older, having taken some part in the regional folding of the region in Loosian times. Connected with them are probably also the diabase dykes, mentioned above, of primary chersantitic or quartz-diabasic composition (analyses No. 20) previously described by the author in the Mansjö memoir (p. 231). Based on the evidence available at that time he suggested that they were younger than the Mansjö granite but possibly intruded at a time when the regional heating of the migmatite area still prevailed. This view has been further confirmed by

Analysis Nr. 20.
Diabasic dyke from Mansjö.
Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	51.20	85.33	Oz . . 7.02	Quartz . . . 14.1	qz + 6	s 56.0
TiO_2	1.10	1.37	Or . . 11.68	Plagioclase	si 124	A 1.9
P_2O_5	0.40	0.28	Ab . . 4.72	($Ab_{14}An_{86}$) . 33.4	ti 2.03	C 8.9
Al_2O_3	17.19	16.85	An . . 38.64	Hornblende(and	al 24.5	F 22.4
Fe_2O_3	2.20	1.37	Σ sal . 62.06	some angite) 29.5	fm 46.0	a 2.0
FeO	7.20	10.00	Di . . 5.41	Biotite . . . 19.1	c 25.0	c 8.0
MnO	0.07	0.10	Hy . . 24.95	Ores 2.7	alk 4.5	f 20.0
MgO	7.39	18.47	Mt . . 3.25	Apatite a. cal-	mg 0.59	n 3.1
CaO	9.70	17.34	Ilm . . 2.13	cite 1.2	k 0.45	k 1.1
Na_2O	0.53	0.85	Pr . . 0.44	100.0	c/fm 0.54	
K_2O	1.93	2.05	Ap . . 0.93			
$H_2O+105°$	0.60	3.33	Σ fem . 37.11			
S	0.25	0.78	H_2O . . 0.60			
CO_2	0.12	0.27	CO_2 . . 0.12			
$H_2O-105°$	0.15	—	99.89			
	100.03					
−O=S	0.09					
	99.94					

Quantitative System: II: 5: 4: 1—2 — *Hessare.*
Osann's Type: No. 97. Frielandorf (s 52, a 2, c 7.5, f 20.5, n 8.5, k 0.90).
Or: Ab: An — 21.22: 8.57, 70.21.
Sp. gravity $\frac{20°}{4°}$ C = 2.872.

the discovery of the additional dyke at Loberget, an analysis of whic (analysis No. 19) agrees fairly well with the one previously publishe of Mansjö. There is only a slight difference of a somewhat higher percentage of soda and a more acid andesinic composition of the felspar This difference may be due to the potash content of the diabase partl being derived from contamination by absorption from the granite as already pointed out by the author in the Mansjö memoir.

In the said paper, the possibility of a connection between the diabase and the Loos-greenstones was suggested, but left to future investigations. No field evidence, unfortunately, has come to light durin the present survey, sustaining or refuting such a connection. Judgin by the different chemical composition and mineral development o the now very well-known greenstones, the assumption of a geneti relationship between the two is not, however, encouraged. Their post-Mansjö age, in common with the Svensbo gabbro-dykes, rather suggest a classifying of the two as an intermediary group prior to the development of the sub-Loosian unconformity. They are, consequently, allotted a place in the archæan age sequence occupied by no correspondin greenstone-dykes in Central Sweden.

In the appended Niggli-diagram, Fig. 7, the analysis of this group of greenstones has been entered together with that of the doubtful Loberget rocks. The number of analyses being too few, the average lines of differentiation must be taken as an indication only, but they show, nevertheless, a marked difference between the two groups.

With the diagram has been compared another rock not mentioned previously, the Harzburgite dyke of Mansjö. No such dyke having been observed outside the syncline, there is no other evidence indicating a younger age excepting the complete absence, both megascopically or texturally, of any dynamic stress features. The diagram suggests, however, a genetic position not very far removed from that of the younger greenstone group, although a recalculation of the analysis (2, p. 241) gives no nephelite in the norm. The evidence being only circumstantial, however, the question of a Mansjö or post-Mansjö age of the Harzburgite remains undecided.

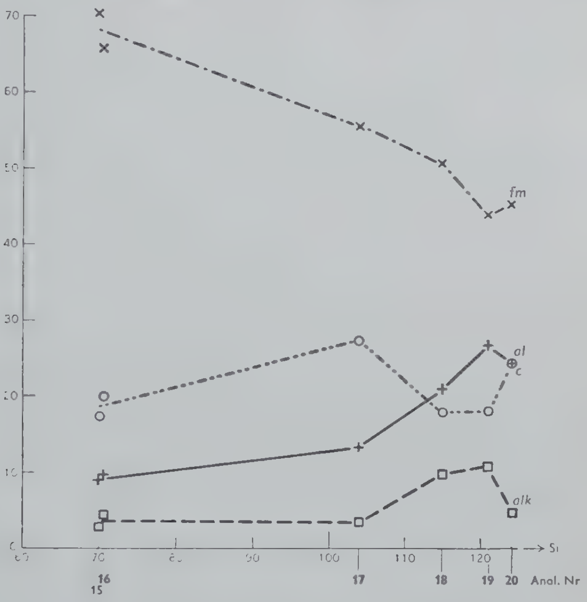


Fig. 7. Niggli diagram of the old greenstones.

The Sub-Loosian Schists.

These series occur, partly underbedding the Loos-series, and partly preserved downfaulted S.E. of Loos. A few small remains spared by erosion also occur to the S. and S.W. of the Loos-area proper.

The formation lies unconformably upon the almost vertical schistosity of the migmatites; their tectonic emplacement has been previously described (cf. p. 147). Their bottom contact towards the migmatites is nowhere exposed, a pink aplitic zone, however, seemingly separating the two. This aplitic horizon was already noticed by E. Norin during the short period I had the pleasure of his assistance, and he drew my attention to its stratigraphic position, expressing his doubts as regards its magmatic origin.

Megascopically this aplite is hardly to be distinguished from the aplites of the Risberg-granites, especially from those emanating from the Dåasen massive. Microscopically, however, they exhibit a decidedly horn-felsic texture quite different from that of the magmatic rocks. Continued detailed study of these aplitic hornfelses, coupled with the discovery of nicely preserved primary beddings here and there have convinced the author of the correctness of Norin's presumption. On the other hand, all aplites found cutting the older and younger rocks have been proved to be really magmatic.

The »hornfels-aplite» may be observed at the S.W. foot of the Fetingsberg ridge, within the steep eastern escarpment of Loosberget, as boulders along the eastern foot of the hills S. of Tensberg, at Kuttermäki and close to the Voxna River S.W. of Kvarnberg. It is, consequently, traceable all along the base of the sub-Loosian series and reminds one of a »sparagmitic» sedimentation resulting from a secular weathering of the old country rocks, viz, a quartzite rich in felspar. Where it is wanting, a conglomerate would be expected instead.

Such a conglomerate, however, was long looked for without success. Norin believed he had found it at the S.W. base of Fetingsberg in the shape of flattened pink pebbles of hornfelses within chloritic schists, but the blasting away of some of the rocks exposed a section of pseudo-conglomeratically stretched and interrupted pegmatite-dykes. Even if the intense pressure imposed upon the rocks at this locality, where the basal sediments of the series are vertically uptilted along the big fault, confuses the issue, there is no doubt as to the character of this conglomerate. Puzzling, however, was the later disocvery of a similar conglomerate at about the same stratigraphic level of the dynamically less affected north-eastern slopes of Fetingsberget, the conglomeratic zone here attaining a thickness of some 20 m. Still more puzzling was a similar occurrence at Kuttermäki S. of Kvarnberg. Renewed study of the last-mentioned localities, especially combined with the examination of slides, has convinced the author of the existence of a real conglomerate, although the first one discovered, which called attention to the formation, has been definitely identified as a pseudo-conglomerate.

Actually, the true conglomerate was found only a few yards from the blastings, the initial confusion being caused by the similarity between the true aplites and the sparagmitic acid sediments.

At Kuttermäki a contact is exposed between the bottom sediments and the superimposed schists, and a section through Kuttermäki establishes the sequence of the sub-Loosian formation in descending order as follows:

Youngest: Cyanite-Andalusite-Cordierite-Schists
White Quartzite
Cordierite-Andalusite-Schists
Phyllitic Biotite-Muscovite-Schists
Biotite-Chlorite-Quartzites with Interformational Conglomerates
Antophyllite-Schists
Blue-gray Quartzites
Conglomerate Zone
Gneissose Mica-Schists.
Oldest: Sparagmitic Quartzite.

The sequence is fully or partly repeated wherever a section is selected at right angles to the strike. The only departure worth noticing is the occurrence of a layer, rich in lime and metamorphosed into diopside-gneiss, at about the same stratigraphic level as that occupied by the antophyllite schists. Actually, the sequence indicates a two-fold sedimentation of different climatic peculiarities. Judging from the conglomerates, the secular weathering of the underlying gneiss-granite, of which no contact has been exposed but which occupies a tectonically unconformable position, must have been fairly extensive, and must have been followed by a sedimentation below sea-level, as evidenced by the composition of the subsequent schists, which grade into slate.

A puzzling feature occurs, however, to which attention may be drawn, even if the author has a difficulty in explaining it. The arenaceous sedimentation series all display »lit-par-lit» injections of numerous granitic dykes, not only of the younger Risberg type occurring at higher stratigraphic level, but also of dykes petrographically and genetically closely connected with the pink Hylen-granite brecciating the leptites at the Hylströmmen Waterfalls. On the other hand, these latter dykes have so far never been found above the conglomeratic horizon. They led the author at first to propose a pre-Mansjö-age of the sub-Loosian series, assuming the latter to be an upper division of the leptites. When publishing his preliminary report, however, the previous view was abandoned, the genetic relationship between the upper intrusions and the Risberg granite being taken as evidence of a post-Mansjö age.

The inference to be drawn from the later establishing of two genetically independent sets of dykes would be the presence of two unconformities, a lower one between the migmatites and the sparagmitic quartzites, and an upper one between the later and the blue-gray quartzites.

The field evidence, however, does not confirm any such division, the bedding of the sparagmitic quartzite being, to all practical purposes, conformable with the sedimentation of the gray quartzites, as is emphasized by their layers of mica and chlorite. On the other hand, the sparagmitic quartzites have been intensely subjected to both pressure and contact-metamorphism by the intruding granites, and most of their potash felspars may be secondary, as evidenced by the ever-present sillimanite, which is the natural by-product of a retrogressive transformation of the micas. The banding, mostly emphasized by magnetite grains, sometimes in conspicuous accumulation, may consequently be a secondary feature, originating under stress on the complete recrystallization of the sediments. This dynamo-chemical coordination of the bedding could, however, only be referred to the agency of the younger granite, which, it is true, has apparently intruded along the base of the sediments, but at the same time had only a very limited corresponding metamorphic influence, when intersecting the upper sedimentary series.

One is actually forced to conclude that an overlapping of the palingenetic magmatic activity into the following erosion period must have taken place at the time when the migmatites, as such, were already formed. This magmatic overlapping, however, is mainly represented by pegmatitic or aplitic late magmatic liquids.

The conglomeratic zone, as well as the distinct change in type of sedimentation must, consequently, in any case indicate an unconformity, even if this is not very great. It constitutes, so to say, an intermediate epoch of lessened orogenetic activity, at the end of which a renewed subsidence of the country to below sealevel ended the waning magmatic activity.

A few other possibilities may also be discussed. One is the alternative of the Mansjö granite never having reached the higher stratigraphic level within the uppermost sediments of the leptite formation, the migmatitization process stopping, so to say, underneath a roof of almost undisturbed horizontal bedding. This conception may find some suport in the Mansjö syncline on the other side of the Loån Valley, where the pitch of the folding axis is still very slight, the whole area constituting a big xenolith floating on top of the granite and migmatite. How this area could be so well preserved supplies food for speculation, and the present author cannot conceive of any other explanation than the subsidence of a part of the roof from magmatically unaffected higher levels into an already fluid migmatitic brew of the older rock series and the granite. A primary unconformity between the Mansjö-series and the older leptite-series is also suggested.

The sub-Loosian series, however, must have been deposited at an enormously higher stratigraphic level if they are of the same epoch as the Mansjö sediments, no evidence of a primary synclinal folding prior to the eruption of the greenstones being preserved, nor any genetic connection being apparent between the sediments themselves.

Furthermore, the two series occupy to-day about the same topographic level, but even if the western side of the Loån is downfaulted, the vertical measure of the slip cannot be a very great one, as demonstrated by the almost equal topographic level of the corresponding sub-Loosian strata at Fetingsberg and Kuttermäki. This clearly precludes any relationship between the Mansjö and sub-Loosian series, and makes the leptitic age of the latter a very problematic one.

Another possibility, however, would be the sub-Loosian series, or their basal part, at least, being the sedimental detritus of the oldest granite and, consequently, the erosion surface representing the sub-Bothnian unconformity. This assumption might do away with some of the difficulties discussed above, but still cannot explain why the Mansjö granite E. of the valley thoroughly engulfs older leptites but, at practically the same level W. of the valley, hardly touches the younger series.

The only rational way out of the difficulty would be to allot one and the same »Risberg-age» to all the dykes intersecting the sub-Loosian. Such an assumption may, to some extent, be justified by the somewhat corresponding chemical character of the Risberg and the Mansjö granites, but as long as the contradictory field evidence has not been explained away, the hypothesis of lingering post-magmatic activity is favoured by the author.

Intrusive within the sub-Loosian schists as sills or sheets are, too, the Loos-greenstones. A fairly large sill of greenstone not far away from a similar one of red Risberg granite is noticeable in the appended section (I—I) of the Kuttermäki district (Pl. CVI).

The petrology of the different strata of the sub-Loosian succession is, briefly, as follows:

The sparagmitic quartzite has already been described above, the mineral composition being merely quartz, microcline, chlorite, biotite, and, accessorily, albite and sillimanite. The chlorite close to the granite is generally transformed into sericitic mica. The sillimanite, however, occasionally assumes the role of a more important constituent, knotty nests being formed of sillimanite and quartz (Faserkiesel) surrounded by zones rich in microcline and poor in mica. They appear on the linear cross-sections of the bedding planes, like knots on a string. The quartz grains are generally optically inhomogeneous within the chlorite zone, but sometimes almost homogeneous when recrystallized within the biotite zone.

In the gneissose mica-schist the micas (muscovite and darkbrown biotite) predominate, the red granulated hornfelsic felspar giving the rock a gneissose appearance. Within this fairly coarse base (size of grains: 1—2 mm) there occur boulders of the sparagmitic quartzite mostly representing the chloritic metamorphic zone.

The blue-gray vitrous quartzites border sharply on the conglomeratic zone and consist at their base of an almost pure quartz of an intense undulatory extinction, the crystal joints being at the same time extremely interwoven, emphasizing the strong dynamic metamorphism. Their texture at crossed nicols may be compared with that of a strongly wind-driven cloudy sky (cf. Pl. XLVIII). Higher up in the series occur occasional bands of chlorite and green biotite as well as small tourmaline crystals, pleochroic from a light violet to a dark neutral tint. Occasionally the tourmaline percentage increases considerably, replacing practically all the biotite. This is the case on the southern slope of Storkvarnberget, where this replacement may be studied in detail (cf. Pl. XVI).

The antophyllite schists constitute a layer of some 5—10 m thickness of parallel strips of biotite(green)-muscovite-quartzite with intervening belts of antophyllite-cordierite schists. A violet to red tourmaline occurring in the latter is rather conspicuous. The antophyllite is almost colourless ($(\gamma - \alpha)_{550} = 0.017$; $2V_{550} = 66° - 70^1/_2°$) and of special interest, as it displays an alteration into a strawcoloured biotite, such a metamorphism being very rare. CHUDOBA, for instance, states that metamorphic changes of antophyllite are »kaum beobachtet». The cordierite crystals are poeciloblastic quartz-cordierite »sponges», and the mineral is partly converted into an isotropic yellow gel-substance partly into a greenish-white, optically positive amesitic chlorite ($(\gamma - \alpha)_{550} = 0.012$—$0.014$).

This stratigraphic level is replaced W. of Karlsberg and at Fetingsberg (southern escarpment) by a sedimentation rich in lime, something like 60 % of the rock consisting of hedenbergitic diopside ($2V_{550} = 60°$, $c/\gamma = 38°$) and 25—30 % of quartz. The balance is microcline and an unusual amount of zircon forming real strata within the rock, emphasizing the old bedding planes. Occasional small bands of cordierite-antophyllite schists are found at higher stratigraphic level too.

The biotite-chlorite-quartzites arise through gradual increase in the number of micacious bands and by the shrinking of the pure quartz layers. On the southeastern slope of Hemtjärnsberget, S.E. of Kvarnberg, interformational conglomerates occur, containing quartzite pebbles of the size of eggs. Ascending the sequence, the quartz is more and more suppressed and the chlorite replaced by white mica until the rocks grade into: (cf. Pl. XXV).

The phyllitic-biotite-muscovite-schists. The biotite, which generally constitutes about $^1/_2$ to $^1/_3$ of the micas but may occasionally predominate, is always of a light green colour, confusingly like that of the chlorite. A distinction between the two is generally impossible in anything but polarized light (cf. Pl. XXIII). The biotite is almost unaxial, while the serecitic muscovite shows $2V_{550} = 31°$. The phyllitic schists are generally somewhat knotty, the quartz grains and grain aggregates being lenticularly elongated in the direction of the strike. A cross-section at right angles to the strike shows a net-like lenticular arrangement of the micas. In many cases it is not even a question of primary quartz grain lenticularly enveloped by mica, but of whole thin quartz layers which, at the stressing of the schists, have been broken and separated. Felspars are sometimes absent but generally present. Microcline may occupy as much as 16—20 % of the rock, but this is exceptional. Albite, on the other hand, is rarely absent and may increase to percentages constituting real albite schists. Some sillimanite, as well as tourmaline, is hardly ever absent, and the latter generally shows a pleochroism between colourless and blue or pink and green (cf. Pl. XXIV).

The phyllitic schists constitute the most important of the sub-Loosian sediments and, apart from variations in bulk of the participating minerals, are unusually alike. The analyses (cf. 22—28) illustrate a chemical range from about pure quartzites to highly argillaceous sediments of almost identically the same composition as the upper Loosian slates (cf. analyses 27 and 57). The close correspondence between the Ställberg-schists (Analysis No. 24), Stenhakersberget (Analysis 26), and the Voxna River N. of Voxna Hed (Analysis 28) is worth emphasizing, as it shows the sedimentation to have progressed very evenly over very large areas. This may be taken as an indication of an extensive regional erosion of the country.

The Fetingsberg schist of Analysis No. 27 differs somewhat from the normal type by the intense corrugation, foliation, and plication

Analysis Nr. 21.

Quartzite. Brook falling into Tikkalampi. (Ls - 117.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %	
SiO_2	95.14	158.41	Quartz	92,3
TiO_2	0.25	0.31	Sericitic Mica	4.3
P_2O_5	0.07	0.05	Albite	1.2
Al_2O_3	1.69	1.66	Apatite	0.1
Fe_2O_3	0.09	0.06	Epidote	0.3
FeO	1.46	2.03	Ores	1.8
MnO	tr.	—		100.0
MgO	0.18	0.45		
CaO	0.17	0.30		
Na_2O	0.16	0.26		
K_2O	0.71	0.75		
H_2O^+	0.28	1.55		
	100.20	Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.637.		

Analysis Nr. 22.

Mica-Schist. Ställstensberget Hill. (Ls - 120.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values
SiO_2	76.79	127.86	Quartz	51.7	si = 513
TiO_2	0.12	0.15	Muscovite	22.4	qz = + 289
P_2O_5	0.16	0.11	Biotite	6.6	ti = 0.61
Al_2O_3	12.29	12.06	Microcline	11.1	al = 48.5
Fe_2O_3	1.00	0.63	Albite	7.3	fm = 25.5
FeO	1.18	1.64	Pyrites	0.6	c = 1.5
MnO	0.03	0.04	Apatite	0.3	alk = 24.5
MgO	1.41	3.50		100 0	mg = 0.55
CaO	0.22	0.39			k = 0.77
Na_2O	0.86	1.34			c/fm = 0.06
K_2O	4.42	4.69			
H_2O^+	1.19	3.36			
H_2O^-	0.07	—			
CO_2	0.00	—			
S	0.15	0.47			
Ni, Co, Cu, Cr	0.00	—			
	99.89	Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.687.			

(cf. Pl. XXI—XXII) affecting the part of the schists caught in the faulting. The potash felspar is all gone and replaced by poeciloblastic sericitic mica, and the biotite has disappeared as well, to give place to a secondary generation of chlorite.

The albitic schists (Analyses Nos. 26 and 28) might also call for a few words, as the origin of the albite schists of the Loch Lomond series

Analysis Nr. 23.

Mica-Schist. Ställstensberget Copper-mine. (Ls - 118.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values
SiO_2	74.34	123.78	Quartz	56.8	si = 430
TiO_2	0.28	0.35	Muscovite	25.3	qz = + 254
P_2O_5	0.11	0.08	Biotite	16.8	ti = 1.10
Al_2O_3	11.28	11.07	Apatite and Ores	1.1	al = 38.5
Fe_2O_3	1.09	0.68		100.0	fm = 40.5
FeO	3.24	4.51			c = 2.0
MnO	0·03	0.04			alk = 19.0
MgO	2.69	6.67			mg = 0.58
CaO	0.36	0.64			k = 0.96
Na_2O	0.10	0.16			c/fm = 0.05
K_2O	5.00	5.31			
$H_2O^{+105°}$	1.21	6.72			
$H_2O^{-105°}$	0.07	—			
(Ni, Co. Cr, Cu not present)					
S	0.11	0.34			
	99.91		Sp. gravity $^{20°}_{4°}$ C = 2.733.		

Analysis Nr. 24.

Albite-Mica-Schist. Main road. South east of Aborrtjärn south of Loos. (Ls 13 - 6.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's System
SiO_2	74.75	124.46	Quartz	37.6	qz = + 179
TiO_2	0.08	0.10	Albite	29.3	si = 415
P_2O_5	0.08	0.06	Microcline	16.7	ti = 0.33
Al_2O_3	12.22	11.99	Biotite	9.5	al = 40.0
Fe_2O_2	1.54	0.96	Muscovite	6.6	fm = 22.5
FeO	2.14	2.98	Apatite	0.3	c = 3.5
MnO	0.02	0.03		100.0	alk = 34.0
MgO	0.72	1.79			mg = 0.27
CaO	0.58	1.03			k = 0.49
Na_2O	3.24	5.23			e/fm = 0.15
K_2O	4.67	4.96			
H_2O^+	0.39	2.17			
H_2O^-	0.08		Sp. gravity $^{20°}_{4°}$ C = 2.814.		
	100.51				

of Scotland has been the subject of some discussion. In the present case, no doubt can be entertained of the primary character of the soda-content of the sediments, as there are no adjoining, nor even remote, volcanic or plutonic rocks which could possibly be made responsible for a select albitisation of specified layers of the schists.

Analysis Nr. 25.

Biotite-Muscovite-Quartzite. Fetingsberg Hill. (Ls - 18.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %	
SiO_2	92.47	153.96	Quartz	84·9
TiO_2	0.10	0.13	Albite	4.4
P_2O_5	0.06	0.04	Muscovite	8·3
Al_2O_3	4.00	3.92	Biotite	1.9
Fe_2O_3	0.08	0.05	Ores	0.3
FeO	0.74	1.03	Apatite	0.2
MnO	tr.	—		100.0
MgO	0.16	0.40		
CaO	0.10	0.18		
Na_2O	0.51	0.82		
K_2O	1.04	1.10		
$H_2O^{+105^\circ}$	0.42	2.33		
$H_2O^{-105^\circ}$	0.08			
	99.76	Sp. gravity $^{20^\circ}_{4^\circ}$ C: 2.671.		

Analysis Nr. 26.

Mica-Schists from Stenhakersberget. (Ls - 13 a.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's System
SiO_2	76.04	126.61	Quartz	42.1	qz = + 236
TiO_2	0.17	0.21	Albite	22.8	si = 456
P_2O_5	0.15	0.11	Microcline	14.9	ti = 0.72
Al_2O_3	12.71	12.47	Muscovite	11.8	al = 45.0
Fe_2O_3	1.05	0.66	Biotite	8.0	fm = 22.0
FeO	2.35	3.27	Apatite, zircon	0.4	c = 3.0
MnO	0.05	0.07		100.0	alk = 30.0
MgO	0.58	1.44			mg = 0.23
CaO	0.48	0.86			k = 0.51
Na_2O	2.52	4.07			c/fm = 0.15
K_2O	3.81	4.05			
H_2O+	0.58	3.22			
H_2O-	0.08	Sp. gravity $^{20^\circ}_{4^\circ}$ C = 2.684.			
	100.57				

The cordierite-andalusite-schists. The higher one ascends in the series, the more advanced is the degree of metamorphism encountered in the schists. Cordierite and andalusite enter the composition either separately or together, in which latter case they are often developed as knots along the cleavages of the rocks. Such is the case on the northern shore of Svarttjärn, E. of Kvarnberg, where extremely knotty cordierite-andalusite-schists are strikingly developed.

Analysis Nr. 27.

Schist. Fetingsberg Hill. (Ls - 24.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values	
SiO_2	56.47	94.02	Quartz	22.3	si	208
TiO_2	0.80	1.00	Muscovite	20.4	qz	= + 40
P_2O_5	0.53	0.37	Sericite	20.3	ti	= 2.52
Al_2O_3	21.17	20.77	(pseudomorphs of		al	= 46.0
Fe_2O_3	0.98	0.61	microcline)		fm	= 34.5
FeO	6.32	8.80	Chlorite	20.6	c	= 2.5
MnO	0.03	0.04	Albite	14.1	alk	= 17.0
MgO	2.63	6.52	Ores	1.2	mg	= 0.42
CaO	0.55	0.98	Apatite	1.1	k	= 0.66
Na_2O	1.67	2.69		100.0	c/fm	= 0.06
K_2O	4.76	5.05				
$H_2O^{+105°}$	3.69	20.48				
$H_3O^{-105°}$	0.16					
	99.76	Sp. gravity $^{20°}_{4°}$ C = 2.766.				

Analysis Nr. 28.

Albite-Mica-Schist by the shore of Woxna Älv River between Rullbo and Woxna Hed. (Ls - 13 c.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values	
SiO_2	74.95	124.79	Quartz	41.2	si	= 439
TiO_2	0.08	0.10	Albite	24.8	qz	= + 223
P_2O_5	0.08	0.06	Microcline	11.7	ti	= 0.35
Al_2O_3	12.72	12.48	Muscovite	11.7	al	= 44.0
Fe_2O_3	1.46	0.91	Biotite	10.2	fm	= 23.0
FeO	2.14	2.98	Apatite	0.4	c	= 4.0
MnO	0.02	0.03		100.0	alk	= 29.0
MgO	0.72	1.79			mg	= 0.28
CaO	0 68	1.21			k	= 0.40
Na_2O	2.64	4.26			c/fm	= 0.18
K_2O	3.77	4.00				
$H_2O^{+105°}$	0.59	3.27				
$H_2O^{-105°}$	0.08					
	99.98	Sp. gravity $^{20°}_{4°}$ C = 2.801.				

The appended analysis, No. 29, of knotty schists N. of Voxna Hed clearly indicate a highly argillaceous rock, viz, an extensively metamorphosed primary slate. The chlorite of this rock is of a secondary nature crystallized parallel to the schistosity of the secondary texture induced by the strong dynamic stress which succeeded the earlier re-

Analysis Nr. 29.

Spotty Andalusite-Sericite Schist. Väster Hocklan brook north of Woxnahed. (Ls - 717.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's System	
SiO_2	60.16	100.17	Quartz	30.8	qz =	+ 78
TiO_2	0.74	0.92	Sericitic mica	28.1	si =	234
P_2O_5	0.24	0.17	Chlorite	12.7	ti =	2.10
Al_2O_3	20.53	20.14	Biotite	8.8	al =	47.0
Fe_2O_3	1.57	0.98	Andalusite	8.1	fm =	36.5
FeO	5.96	8.29	Albite	7.4	c =	2.5
MnO	0.02	0.03	Ores	3.6	alk =	14.0
MgO	2.10	5.21	Apatite	0.5	mg =	0.34
CaO	0.54	0.96		100.0	k =	0.80
Na_2O	0.76	1.23			c/fm =	0.06
K_2O	4.53	4.81				
$H_2O^{+105°}$	2.69	14.93				
$H_2O^{-105°}$	0.22	Sp. gravity $\frac{20°}{4°}$ C = 2.809.				
	100.06					

gional metamorphism. No potash felspar is present, but some green biotite and albite are part of the composition.

An extremely beautiful, finely plicated sericite-cordierite schist, exposed at Hemtjärnsberget, is worth pointing out. It is of a silky, pink sheen and owns its colour to the presence of innumerable, small, strongly pleochroic, manganese-epidote crystals. The close proximity to the big sill of Risberg granite, outcropping to the N., may be responsible for this unusual type of metamorphic schist.

The upper quartzites. The argillaceous sedimentation is interfoliated at a higher level with a bed of white quartzite of about 10—20 m thickness, carrying as predominating constituents quartz and sericitic mica and accessorily albite, ores and small grains of a wine-red manganese-epidote. The chemical composition is given in analysis No. 21. Occasionally, the upper quartzite beds are of imposing thickness, such as at S. Kvarnberget, where the schists are reduced to very narrow bands. Where the quartzite is thinner, however, such as at Ställberget, it has undoubtedly taken part in the intense folding of the schists, as is evidenced by its strange micro-texture of pure quartz grains in a plicated arrangement, reminding one of the contorted Fetingsberg schists (cf. Pl. XVI). The heavy quartzite deposits previously mentioned have not bent so easily to the folding, and are bounded by faults relieving the tension. The microscopic appearance of the quartz grains is, too, devoid of any tectonical orientation, even if, optically, they are very badly strained.

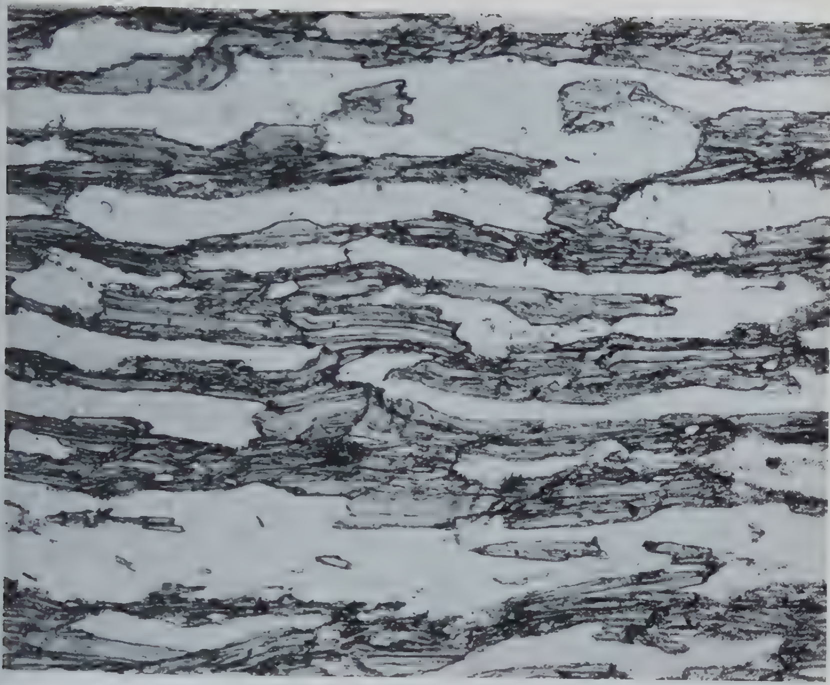


Fig. 1. Sub-Loosian biotite-chlorite-schist from Ställstensberget. The gray mineral is biotite and chlorite, the white one is quartz. Ord. light. Magnif. × 55.

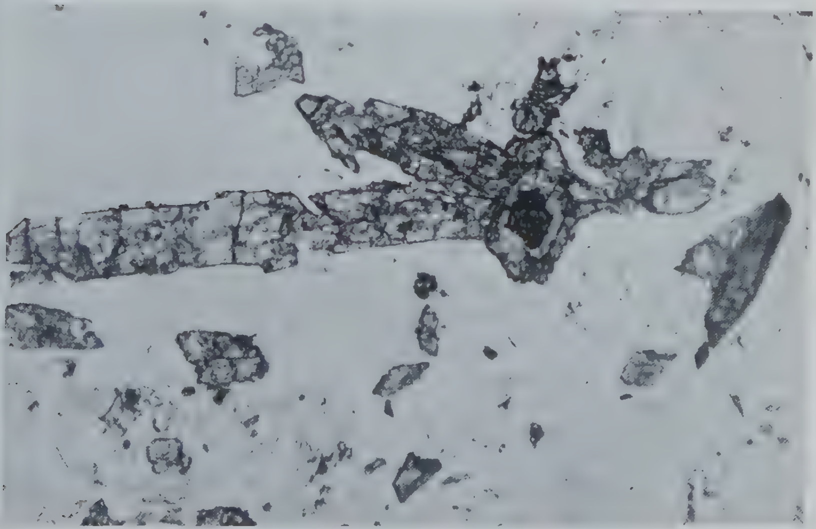
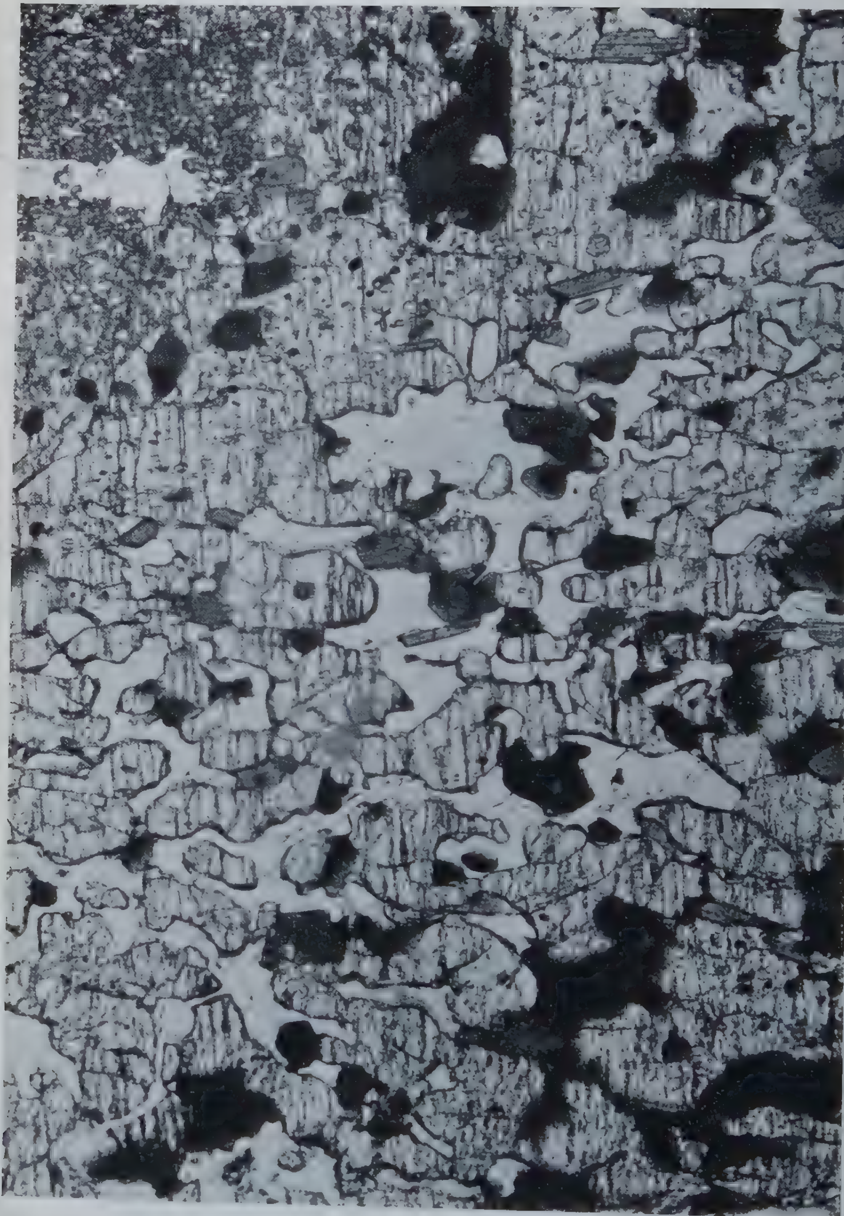


Fig. 2. Pink manganese-epidote with kernel (dark) of allanite. Sub-Loosian mica-schist at N contact towards sill of Risberg granite at Hemtjärnsberget. Ord. light. Magnif. × 35.



Sub-Loosian andalusite-schist W of Storlugnet, Woxna Älv. The poeciloblastic andalusite is intergrown by quartz and tourmaline (upper left corner). The larger black crystals are biotite. Ord. light. Magnif. × 55.

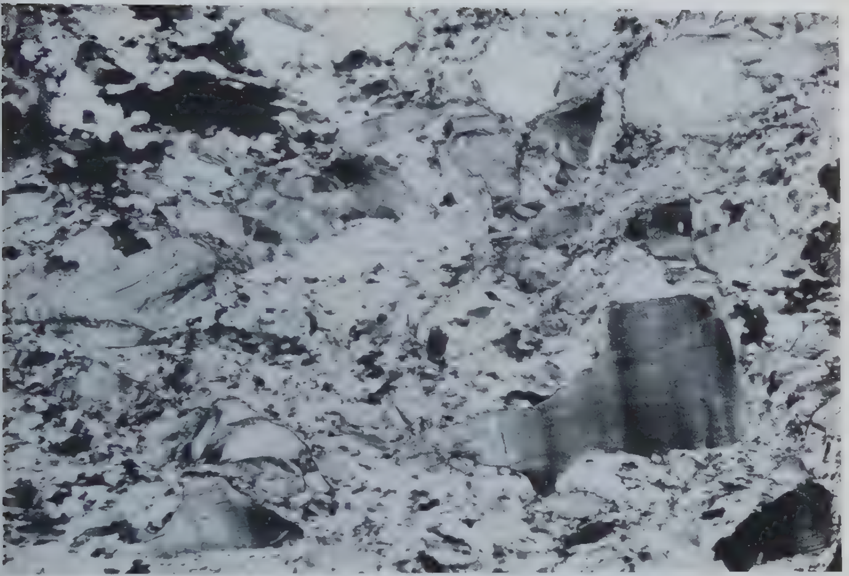


Fig. 1. Quartzitic mica-schist SE of Abborrtjärn. The dynamic metamorphism is indicated by the contortion of the micas. Nic. +. Magnif. × 10.

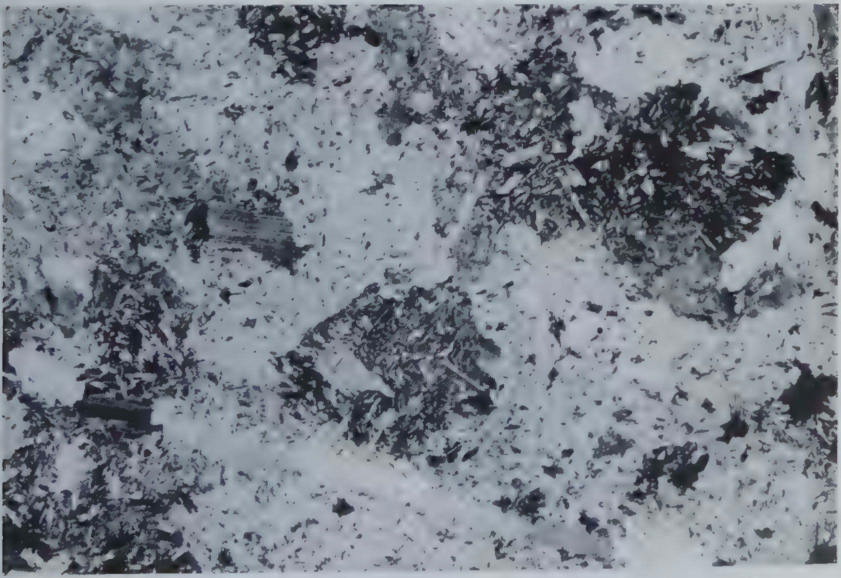


Fig. 2. Basal conglomerate of the Lower Loos Series, S of Losberget Cottage. Microcline grains (dark) filled with sericite. A quartz-breccia fissure crosses the picture. Nic. +. Magnif. × 10.

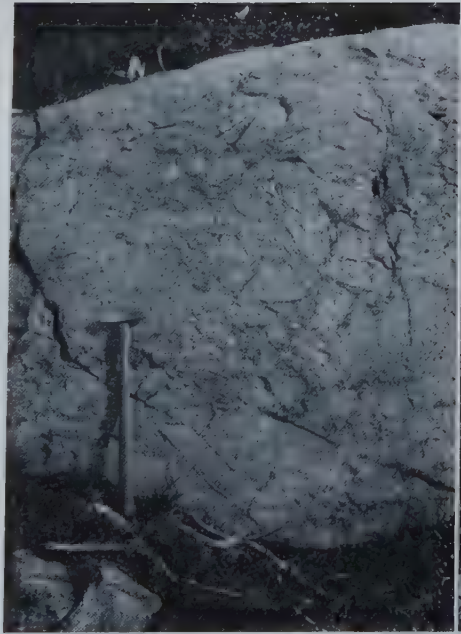


Fig. 1. The old land surface underlying the Lower Loos Series, S of Losberg Cottage. It is composed of angular fragments of quartzites and pebbles of gneiss-granites.

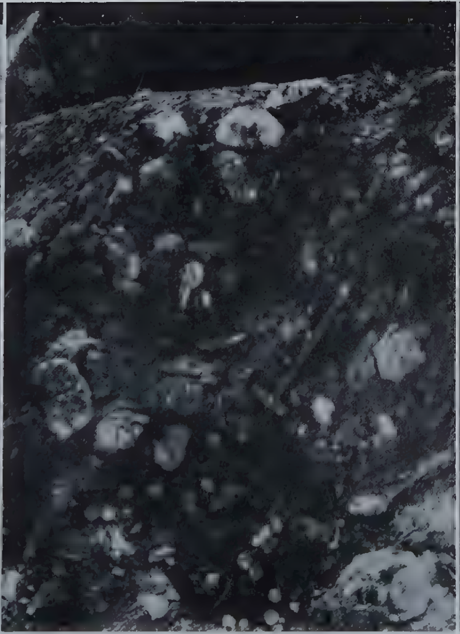


Fig. 2. The conglomeratic zone at the top of the Sub-Loosian schists, E of Tenskog.

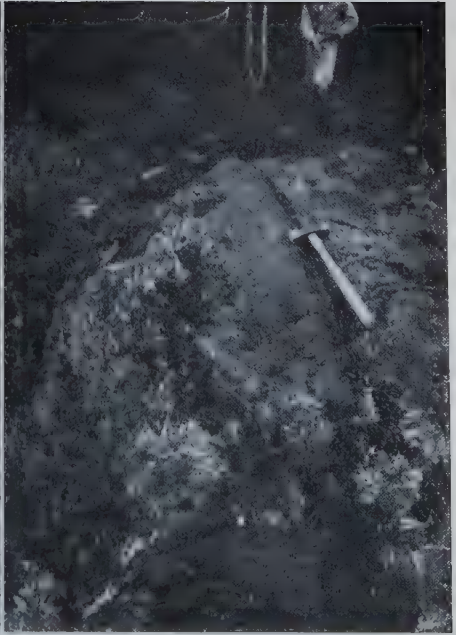
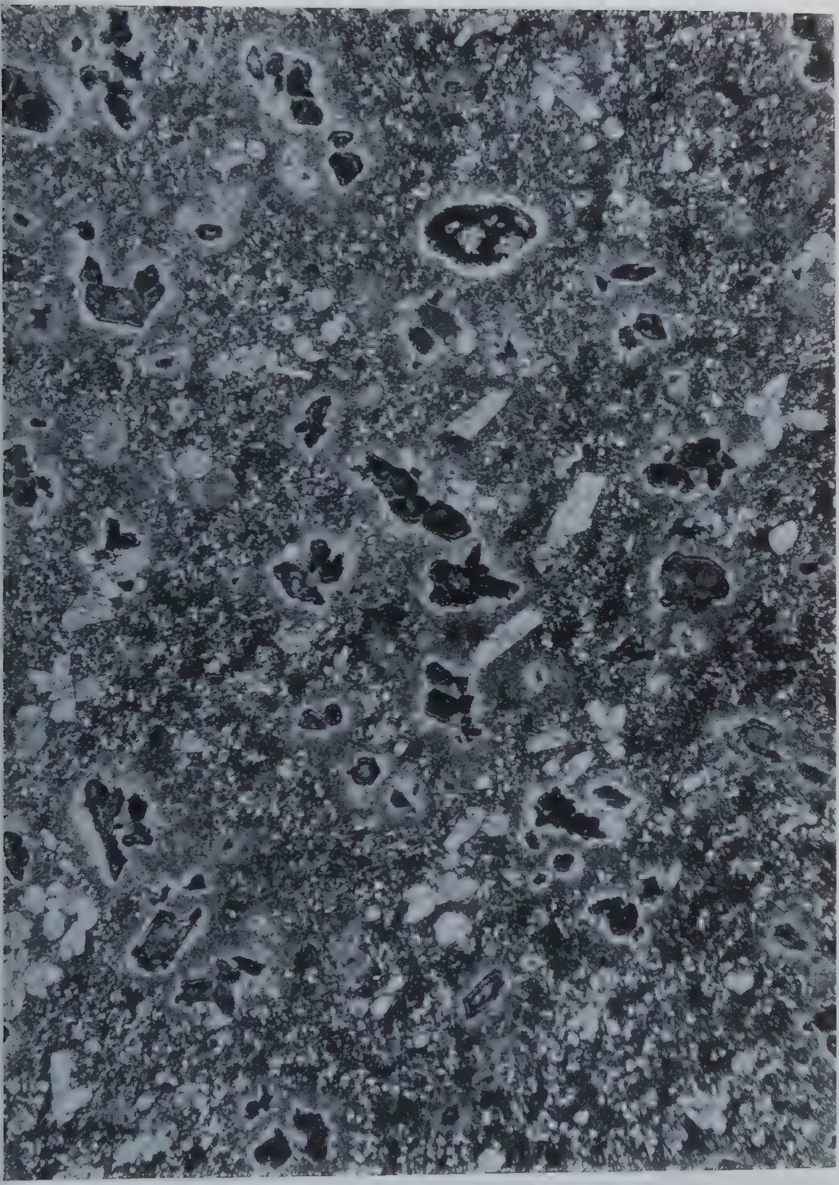
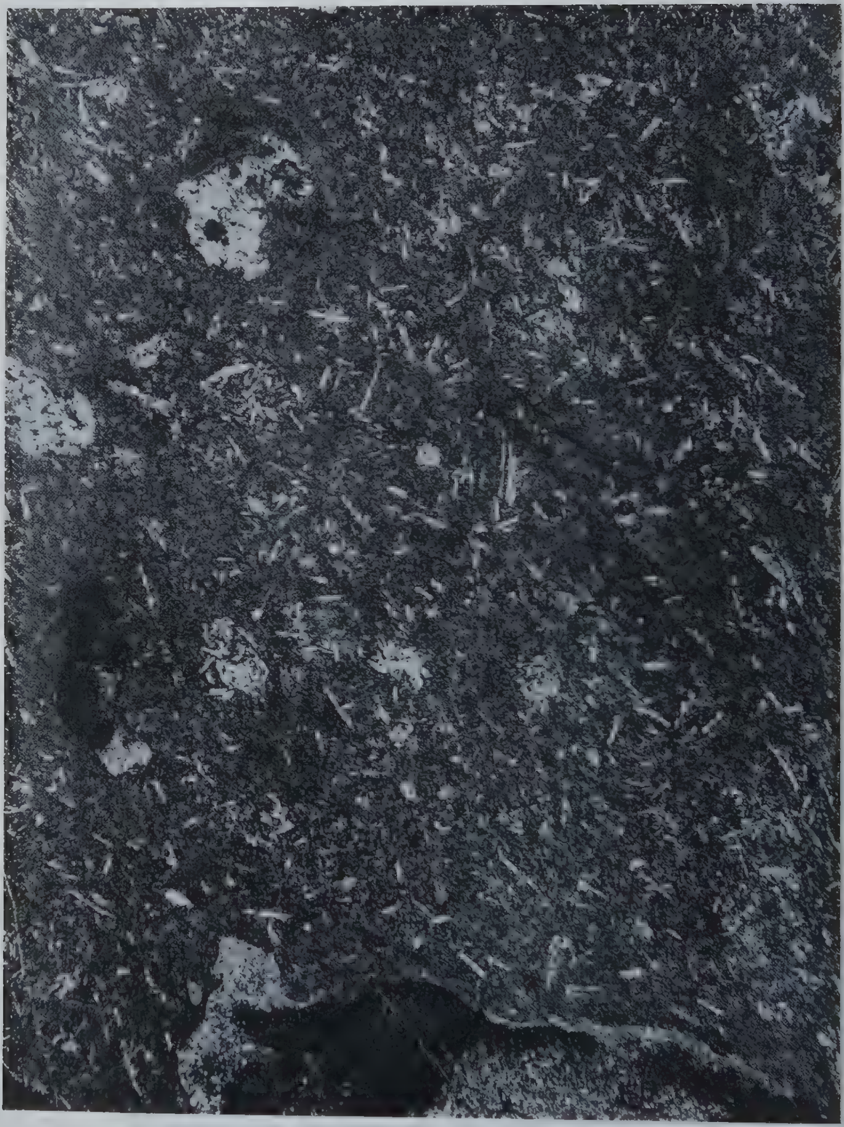


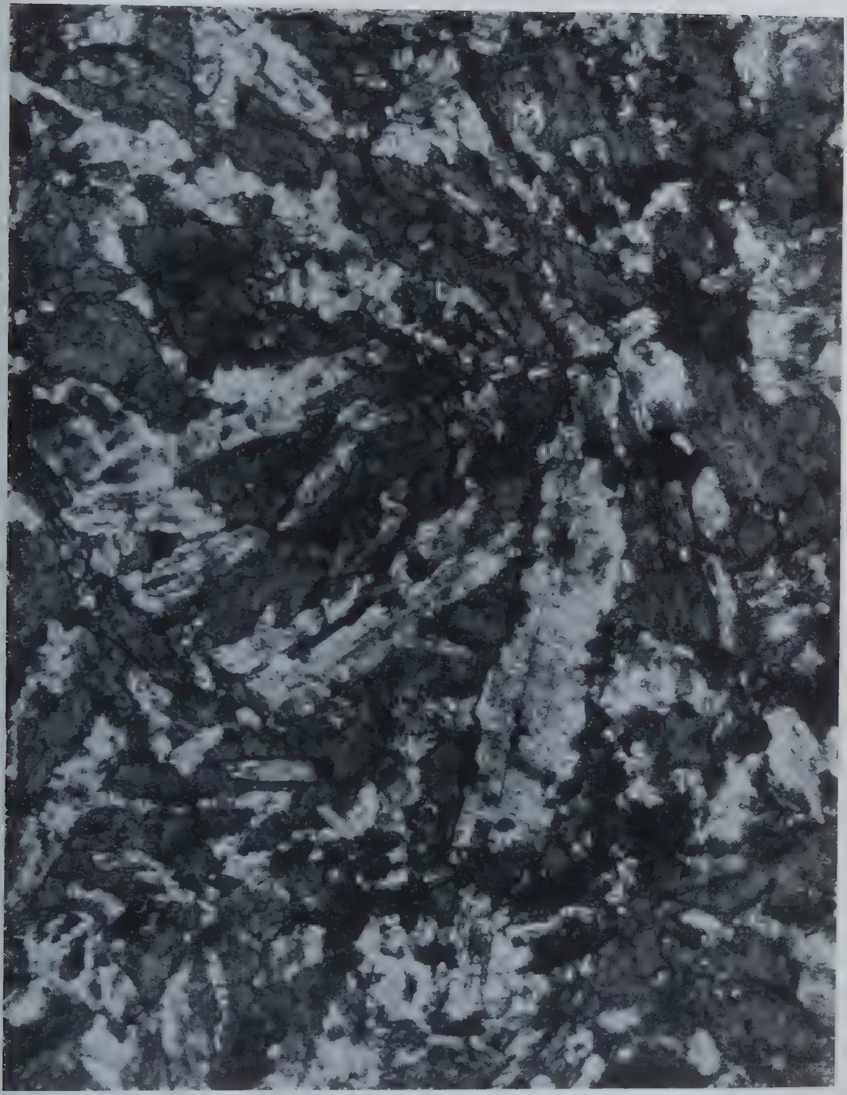
Fig. 3. The contact between the underlying granite-arkose to the right, and pelitic Loos quartzite to the left, E of Noppikoski.



Greenstone dyke from Björkberg. Light-coloured crystals are augite, dark crystals are olivine-pseudomorphs, surrounded by light-gray edenite-reaction-rims and medium gray biotite. The small dark spots of the base are hornblende-prisms. Ord. light. Magnif. × 10.



Effusive greenstone of primary diabasic texture, from Loos Village. A great vesicle at the bottom of the photograph. Ord. light. Magnif. × 10.



Loos greenstone of primary ophitic texture at N. Hocklan. The dark areas are green pigeonitic pyroxene. Ord. light. Magnif. × 40.

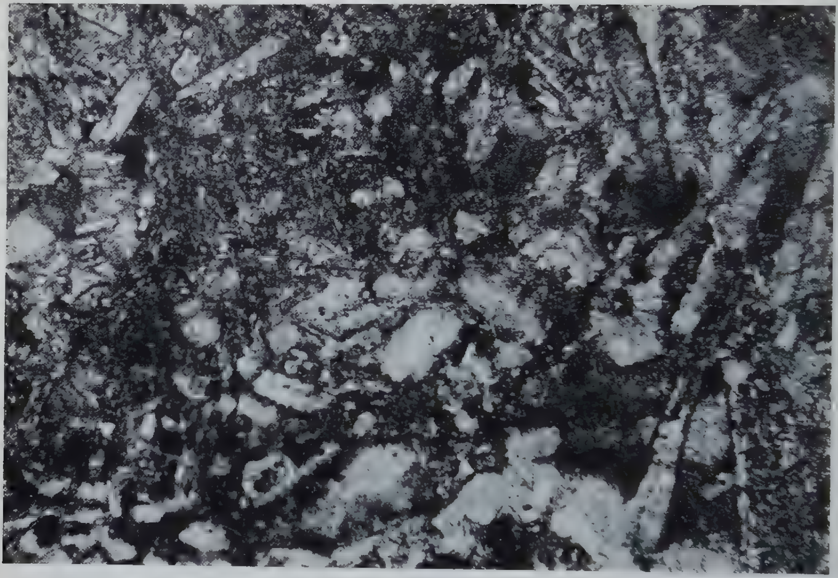


Fig. 1. Loos greenstone of sub-doleritic texture from Bygget. Ord. light. Magnif. × 40.

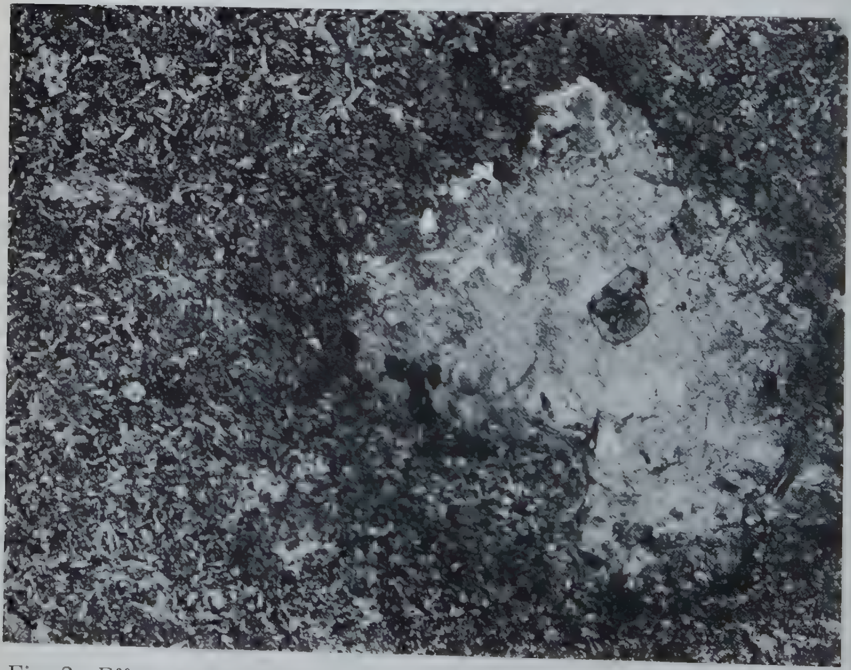


Fig. 2. Effusive greenstone of primary diabasic texture from Loos. Dark zone of hornblende surrounds the vesicle, which is filled with chlorite (medium gray), quartz (white), calcite (light gray) and a central pistazite grain. Ord. light. Magnif. × 10.

The cyanite-andalusite-schists following on top of the quartzite would be quite similar to those underneath but for a conversion of some of the andalusite into cyanite. They occur in the immediate vicinity of the big fault E. of the greenstones.

The different modifications of the Al_2SiO_5-minerals within the sub-Loosian schists agree very well with the supposed tectonic evolution. High stresses have undoubtedly prevailed at the base of the sediments during the regional metamorphism, and sillimanite has been the stable mineral. Where the shearing stress has been lessened by the pegmatitic intrusions of the conglomeratic zone, the relaxation has not been strong enough to disturb the stability of the sillimanite, even if it has slightly altered the anthophillite and led to the formation of cordierite. At intermediary stratigraphic levels no thermal influence of the granite has been active but as we approach the granites the thermal readjustment gradually increases, the sillimanite being replaced by the anti-stress andalusite.

Finally, at the big down-faulting and sharp folding of the schists following the eruption of the greenstone, an intense shearing stress must have set in anew, creating the conditions necessary for the formation of cyanite within those parts of the schists affected by the movements. Cyanite is also quite conspicuous in the schists caught in the partial faults W. of St. Kvarnberget.

As already intimated, the complete sequence exposed at Kuttermäki—Hemtjärnsberget—St. Kvarnberget, does occur elsewhere within the area but in certain parts only. A few of those may be especially mentioned.

At Fetingsberg, only the bottom half of the series remains, strongly metamorphosed by the pegmatites of the Dåasen granite wherever the latter intrudes the grayish-green albite-biotite-sericite-phyllites. They are converted into rather coarse pink gneissose schists of microcline, colourless quartz and mica, the albite dropping to small percentages and the accessory magnetite being oxidised, marginally or totally, into hematite. These pink, muscovite-microcline-quartzites are traceable as contact zones around the pegmatites. This is nicely shown S.E. of Aborrtjärn near the highroad, where a pegmatitic dyke cuts obliquely across the schists.

At V. Håcklan and Voxnaälv, N. of Voxna Hed, the arch of vertically tilted sub-Loosian sediments bordering on and interfoliated by the Risberg granite represent only the upper part of the succession, while the remains of somewhat lower strata are found intensively foliated and metamorphosed S.W. of the river. A small occurrence o white granular quartzite down at the river and close to the superimposed tuffitic Loos-series is undoubtedly thermally recrystallized and is supposed to represent the upper white quartzites. Their tectonic position is abnormal, the older schists to the S.E. most certainly having been thrust over them.

A fairly large, probably down-faulted, triangular area of the lower quartzites is shown on the map to occur S. of Kuttermäki. Other small quartzitic areas also remain farther to the W. At Tackåsen E. of Noppikoski, occurs a coarse gray quartzite of somewhat doubtful position. Petrologically, it shows a certain likeness to the sub-Loosian series and has been provisionally mapped as its lower strata. Metamorphically, however, it is totally recrystallized, almost gneissose The adjoining Risberg granite may be responsible, — if it is not, its age might be leptitic.

At Råberg, N.E. of Noppikoski, the basal strata of the Loos-quartzites are of a somewhat sub-Loosian character and will be discussed later (cf. p. 239).

Questionable is, too, the mapping of the sedimental series exposed along the new road from Ö. Hamravallen to Raisberget (N. of Hamra) as sub-Loosian. The quartzitic mica schists at Raisberget as well as the quartzites about 700 m N. of Hamravallen are microscopically like the corresponding parts of the lower sub-Loosian. The dense banded rocks intersected by granites and occurring immediately N. of Hamravallen, on the other hand, have no correspondence with the sub-Loosian series, and strongly remind one of the banded leptites of Central Sweden The injecting pegmatitic granite also has an undesirable likeness to the Mansjö type. The rocks are cut, however, close to the outcrops by the young Rätan granite, which lies adjacent in a great massive towards the W. and which has certainly had a very strong thermal influence on the schists.

This thermal metamorphism may, of course, have confused the issue and may be responsible for the different habits of the rock. The tectonic emplacement of the schists and their strike at right angle to the general schistosity of the old granites are the only evidences suggesting a connection with the sub-Loosian rocks at Voxnaälv. No additional outcrops having been found in the neighbourhood, the question of the true age must be left open and the possibility of part of this area being of leptitic age will have to be borne in mind.

The Lower Loos Series.

The Unconformity Overlying the Sub-Loosian:

The »classic» locality of this unconformity is located S. of Losberget Cottage, a few metres E. of the road where it was first found when tracing the ice movement of conglomeratic boulders, and exposed by digging. By courtesy of the landowners, the Bergvik-Ala Company, to whom I herewith express my thanks, permission was obtaind to leave the main exposure uncovered, while the diggings across the contact with the Loos-series had to be filled in again, as they interfered with the maintenance of the main road to Loos.

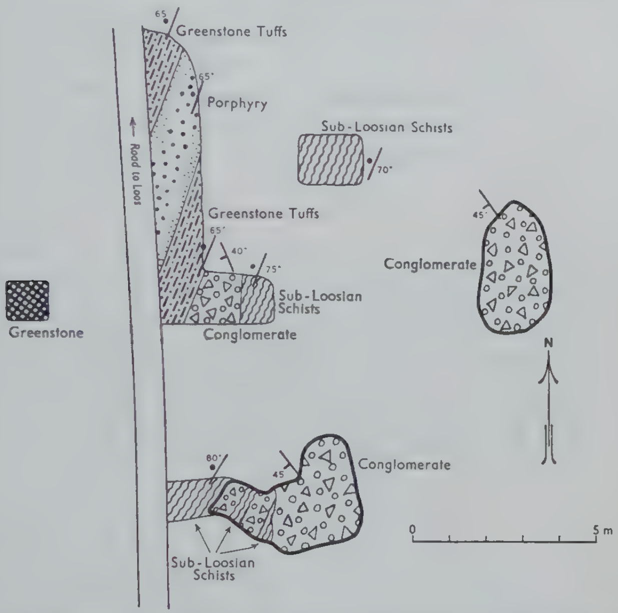


Fig. 8. Sketch-map of the sub-Loosian unconformity south of Losberget Cottage.

The present exposure presents the picture of an old land surface (Pl. XXVIII, Fig. 1) composed of small rounded pebbles of old gneiss granites and quartz filling the interstices between sharp fragments of quartzites and schists, the whole cemented by a gritty matrix. The descending succession of this polymikt talus-conglomerate grades into the biotitesericite-albite schists. In the now covered trench, dug towards the greenstones on the other side of the road, tuffitic greenstone was found to overlie the sub-Loosian unconformably, while, at a distance of a few yards, in one of the cross trenches, Loos quartz porphyry cut the tuffites and the conglomerate, exhibiting toward them chilled felsic margins. The details of the locality are shown b the sketch, Fig. 8.

This unconformity has been traced some 2 kilometres to the N., a well as southwards to Kvarnberg N. of Kuttermäki. Here and ther it is disturbed and obliterated by the big N.S. fault; at other places i is still preserved. W. of Svarttjärn the old land-surface cuts throug the quartzites, conglomerate pebbles appearing within the quartzit and schists in increasing quantities when approaching the greenston (cf. Pl. XXVIII, Fig. 2). The unconformity is also established b quartzite fragments engulfed by the greenstone S.W. of Hjärpberge Cottage, and by the greenstone brecciating the upper quartzites i the neigh- bourhood of Svarttjärn. The sedimentation of the greenston tuffites N. of Svarttjärn is also at a noticeable, even if low, angl to the schists.

The base of the greenstone lavas has undoubtedly extruded over land surface strewn with loose pebbles and boulders. Extensive basa greenstone agglomerates are found, partly as big boulders along th road to Loos from Voxna, but also in solid outcrops at the base of th greenstone escarpment, E. of Loos village. These agglomerates contain besides fragments of old schists and quartzistes, an unusual amount o rounded pebbles of Mansjö granite and migmatites.

The Greenstones.

The main greenstone area around Loos consists of old basaltic lav flows erupted from a N.S. fissure. Probably the greater part of th eruption took place above sea-level as no typical pillow structures hav been found. The greenstone lies evidently unconformably upon a slightl eroded surface of the sub-Loosian schists, bordering partly on the schist and partly on the quartzites. Greenstone breccias of quartzites ar conspicuous in the southern part of the field round Tennskog. Larg areas of pyroclastic tuffitic greenstone occupy about 50 % of the area the remaining part exhibiting quite recognisable lava flows, one on to of the other. These flows may, for instance, be examined on the north western and western slopes of Hjärpberget, where they dip toward the W.

While the central part of these flows is dense or medium-grained, th top of the flows generally consists of a highly vesicular rock, the vesicle being filled by quartz and calcite. Even the base of the flows sometime contains blow-holes but generally less plentiful and of smaller size.

Between the flows, agglomerates are occasionally exposed. They consist of effusive and solid greenstone fragments, sub-Loosian schists, old gneiss granites and pebbles or lumps of a keratophyric rock unknown in solid outcrops anywhere. When blasting a culvert for the water system of the Loos village some years ago, a striking section of such an agglomerate was temporarily exposed N. of the church.

The thickness of each flow varies from 10—20 ft and the minimum total thickness may be computed as being 300 ft. Towards the base, some of the lavas exhibit a rather coarse-grained gabbroid texture, as may be observed in the eastern escarpment of the hill, E. of Tennskog.

The greenstone also intrudes its own pyroclastic rocks, such intrusive sheets being conspicuous S.E. of Tennskog and N.E. of Loos in the valley N.W. of the Dåasen Hill. At the latter place, however, the intense folding has disturbed the original emplacement of the rocks to such an extent that the »lit-par-lit» injections (cf. map) may be partly secondary.

The greenstone lavas — their mode of extrusion probably being that of the plateau basalts — have apparently extended over a far greater area than that existing at present. Even if the greenstone occurrences at Loberget, — in the writer's preliminary report referred to as Loos greenstones — are now believed to be old-archæan, a small relic of Loos greenstone occurs at Lillskog village E. of the Loån river, as well as at Njupaklitt N. of Voxna. Although an E.W. fissure eruption, the former is certainly contemporaneous with the N.S. main eruption.

A small system of fissure dykes, W. of the Voxna River at Björkberg, may be taken as the feeding dykes of previous eruptions in those parts. As far W. as Tandsjöhållan Hill, on the eastern shore of Lake Tandsjön, a large xenolithic area of Loos-greenstone is found submerged in the Rätan granite magma.

An abundance of partly effusive greenstone boulders, S.W. of Rullbo along the new road from Hamra, indicate a greenstone area somewhere towards the N.W., but diligent search has so far failed to reveal any outcrops.

The greenstones are cut by a number of small peculiar dykes especially plentiful in the Tennskog district and strikingly conspicuous in the field on account of their white colour. These dykes are undoubtedly late offshoots of the greenstone magma itself, and will be discussed later on, under the new name, »Andesinites». They do not occur outside the greenstone mass itself. The latter is also intruded by other rocks of younger age, such as the Risberg and Rätan granite as well as the jotnian doleritic diabase. A small dyke of this diabase, not shown on the map, occurs at Karlfors, N. of Loos.

In its best preserved parts, the Loos greenstone is frequently of an ophitic or diabasic texture, the dense and probably originally chilled types being those least affected by later metamorphism. In the coarser grained rocks, most of the primary features are obliterated (cf. Pl. XXX—XXXVI).

The normal mineral constituents of the greenstones are a pigeonitic augite, a light coloured greenish hornblende, plagioclase, magnetite, ilmenite and pyrites. In the more highly metamorphic rocks biotite, epidote and chlorite are present too.

The feeding dykes exposed in the deep-seated erosion section at Blommaberg present some difference, both in texture and in mineral composition. Their texture is not ophitic but granular; beautifully crystallized pyroxene crystals and olivine-pseudomorphs occurring in a ground mass of short green amphibole-prisms, small grains of pyroxene and colourless felspar. The pyroxene is of pigeonitic composition the following optical characteristics having been determined:

$$c/\gamma = 30^\circ;\ 2V_{550} = 47.5^\circ;\ (\gamma - \alpha)_{550} = 0.024.$$

The primary olivine is clearly marked by the ore skeletons indicating the original boundaries of the crystals, but the mineral is totally metamorphosed into a mixture of a yellow-greenish biotite and equally coloured edenitic amphibole. The biotite displays a small axial angle of 4°—5° and the optical values of the edenite are as follows:

$$c/\gamma = 16^\circ;\ 2V_{550} = 82^\circ;\ (\gamma - \alpha)_{550} = 0.023.$$

The amphibole of the ground mass shows a pleochroism varying from a bright olive green to a yellowish green, being characterized by somewhat different optic values:

$$c/\gamma = 14^\circ;\ 2V_{550} = 81^\circ;\ (\gamma - \alpha)_{550} = 0.016.$$

This indicates a hornblende fairly rich in soda. The somewhat zonar felspar, occurring mostly within the interstices between the mafic minerals, is an albite of the composition An_{12-18}. Albite twinning is observed only occasionally.

The nicely developed primary augite of this type of rock has, however, more or less disappeared in the lava flows — even in the least altered — and has been replaced by brush-like radiating hornblende. Where the augite remains, it is slightly greenish with an extinction angle of 27°—28° and an axial angle of $2V_{550} = 73^\circ$. The birefringence was measured as $(\gamma - \alpha)_{550} = 0.029$; indicating a pigeonitic augite, although of a composition somewhat different from that of the feeding dykes. The above values were determined on samples from an unusually well-preserved part of the small occurence at N. Håcklan, N. of the road to Rullbo. The sample was taken from what was presumed to be the bottom portion of a lava flow. Towards the upper part of the flow, the pyroxene disappears, at the same time that the acidity of the plagioclase as well as the percentage of secondary hornblende and epidote increases. While the felspar at the bottom part is approximately An_{60} it grades into An_{37} at the top. Another flow, however, contains only albitic oligoclase of a composition varying between An_6 and An_{10}. The basic plagioclase of the first lava-bed displays nicely shaped lathes stained slightly brown by pigmentation, while the acid plagioclase-lathes of the latter either present sinuously corrugated outlines or are granulated (cf. Pl. XXXI).

The amphibole is of a light greenish hue, slightly pleochroic and of the following optic constants:

$$c/\gamma = 16°;\ 2V_{550} = 76°;\ (\gamma - \alpha)_{550} = 0.018.$$

The greenstone xenolithe at Tandsjöhållan contains a simply twinned plagioclase varying between An_{51} and An_{53} and a strongly pleochroic amphibole ($c/\gamma = 15°$) bluish green to colourless, indicating a relatively high percentage of soda. Taking the field as a whole, the plagioclase of the greenstone may be said to vary normally within the flows from andesinic to albitic, viz, from An_{37} to An_6, but in many instances, at higher stratigraphic level especially, even the bottom part of the flows contains very albitic felspar, from about An_8 to An_{10} being a common average. Repeated albitic twinning very rarely occurs in the primarily preserved greenstone, even simple twinning sometimes being rare.

We may, consequently, speak of a gradual albitisation of the greenstone, increasing from lower to higher level, not only within the consecutive flows but also, in a lesser degree, within the flow sthemselves. There is hardly any doubt of this albitisation being an autogeneous process, developed within the greenstones themselves. Its evolution may also be followed by watching the development of the amphiboles, growing from small scattered radiating patches into large brush-like aggregates interweaving the whole texture of the rock, and finally destroying its primary ophitic texture (cf. Pl. XXXIV). No analyses have been made of this hornblende, but it has all the characteristics of one rich in lime. As the albitisation proceeds, epidote, too, is formed in the vesicular and effusive part of the lavas. This epidote is always a pistazite rich in iron, $(\gamma - \alpha)_{550} = 0.046$. It occurs as grains or solid shells around the vesicles, sometimes replacing hornblende, and is also found within the vesicles themselves as a result of secondary thermal metamorphism, wherever the greenstone comes into close proximity of the younger granites. Generally, the vesicles are filled with quartz and calcite, and sometimes with nicely crystallized grains of pyrites. Another not uncommon filling of the blow-holes is a greenish-brown biotite with a core of greenish chlorite and quartz, all enclosed within a lining of hornblende. This latter mineral succession reflects, so to say, the changing stability-relationship, at increasing temperature and increasing pressure, succeeding the primary crystallization within the vesicles.

A certain amount of greenish biotite, almost undistinguishable at first sight from the hornblende always occurs in the greenstones. All the potassium seems to be normally bound as biotite, no orthoclase nor microcline being present. Another evidence of the progressing autogeneous albitisation is given by the streaks and sometimes by fairly large areas of diffuse accumulations of albite, which, so to say, dilutes the greenstone and even occurs as a dense, pure albite-fels. This albite-fels, being closely related to the last gaseous and hydrothermal transfer in the magma, is more or less accompanied by quartz and is also found to locally brecciate previously solidified rocks. This is not easily observed in the outcrops, but some nice examples were brought to light in the drill cores recovered from the prospecting borings of the Boliden Company.

To these late-magmatic albitic concentrations there are also bound ore-concentrations which, in the 18th century, gave birth to extensive mining in the Loos Hills. These ore bodies — or, rather, impregnated ore zones — occur mostly in the vicinity of the boundaries towards the surrounding rocks, and in some cases, as at Ställstensberget, even the sub-Loosian schists are enriched. A natural explanation may be the trend of the volatile solutions to move in the direction of least resistance and lowest pressure, viz, towards the porous schists. The old mines around Loos Village were worked in the years 1721—1773, during which time a copper smelter was built and a factory erected which produced blue cobalt dyes. The cobalt ores, however, were not mined from the above-mentioned albitic greenstones, but from a N.S. calcite-filled fissure in the lava, which may be supposed to represent an ancient volcanic vent, in which exhalation products of the late magmatic activity had been deposited. This deposit proved, however, too small — 2 in. being the average, and 2 ft. the maximum width — to be of any real commercial value, and the mining came to an end at the end of the 18th century. In 1917, the mines were pumped dry by some optimists and the present author had an opportunity of inspecting the old workings. The »ore» was found only as a small calcite fissure, about 1 in. wide, at the bottom of the mine and proved almost devoid of any ore minerals and was, consequently, quite valueless.

The minerals recorded from these mines are pyrites, pyrrhotite, chalcocite, chalcopyrite, sphalerite, galenite, arsenopyrite, niccolite, smaltite, cobaltite, native bismuth, bismuthenite and fahlerz. A thorough mineralogical survey would probably add to the list.

Even if the mines were economically a failure, scientifically they are of historic fame. It was in a sample said to be derived from Loos that in 1752 the Swedish chemist CRONSTEDT, discovered the element nickel, which was certainly a strange incident, as no nickel mineral was mined at the time and a later diligent investigation of the dumps has failed to reveal the slightest trace of any. The present author even went to the trouble of turning the dumps bottom up by means of a charge of dynamite. Three years ago, however, the Boliden Company pushed one of their drill holes through about $^1/_2$ metre of high grade nickeline-ore within the greenstone, W. of the old mines, thus confirming the correctness of the earlier statement. Recent prospecting at Loos has not given any encouragement for the revival of the mining activities of bygone days. No workable gold was found, although some amount of silver and a fair percentage of copper was proved to be present. Unfortunately, the comparatively small size of the ore concentrations and the great distance from any shipping centre, exclude at the present price-level any economic exploitation.

The chemical evolution of the Loos greenstones from their hypabyssic to their effusive phases is of special interest, as it may contribute to the lately rather lively discussion on the subject of spilitic magma.

There is hardly any doubt of the spilitic character of the effusive members of the Loos-lavas, even if their extrusion can be supposed to have mainly occurred above sea-level.

The following six analyses, Nos. 30—34 b, were carried out, and clearly indicate a close similarity to earlier published analyses of spilitic rocks. They represent the feeding dykes, the bottom portion of the flows, the solid and effusive upper part and, finally, the andesinic late magmatic dykes from hypabyssal depths.

Attention is immediately drawn to the undersaturated character of the more deeply seated rocks as expressed by a decreasing series of nephelite in the norm, from 8.84 in the feeding dykes, through 2.50 in the bottom of the flows, to 0.29 in the andesinite. Computing a variation-diagram according to NIGGLI one may, consequently, conceive a splitting up of the differentiation into two sequences, one of the more deep-seated, and one of the effusive rocks (cf. Fig. 9). The former leads through a rest magma of a composition somewhere between the central and outward part of the andesinitic dykes to pure andesine, and the latter leads to almost pure albite. The concentration of titano-

Analysis Nr. 30.

Greenstone Dyke at Stenberg Hill, Björkberg (Ls - 633).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	46.29	77.07	Or	11.72	Amphibole	30.0	qz	−40	s	48.4
TiO_2	0.75	0.94	Ab	8.32	Plagioclase		si	94	A	4.2
P_2O_5	0.00	—	An	15.32	($Ab_{82}An_{18}$)	20.9	ti	1.10	C	3.3
Al_2O_3	12.53	12.29	Ne	8.84	Biotite	20.6	al	15.0	F	35.1
Fe_2O_3	3.42	2.14	Σ sal	44.20	Pyroxene	20.1	fm	52.5	a	3.0
FeO	6.31	8.78	Di	29.58	Ores	6.4	c	24.0	c	2.5
MnO	0.17	0.24	Ol	16.87	Calcite	1.0	alk	8.5	f	24.5
MgO	12.07	29.94	Mt	4.88			mg	0.69	n	6.9
CaO	11.07	19.74	Ilm	1.40		100.0	k	0.30	k	0.72
Na_2O	2.94	4.74	Pr	0.39			c/fm	0.46		
K_2O	2.00	2.12	Cc	0.88						
$H_2O^{+105°}$	1.47	8.16	Σ fem	54.00						
CO_2	0.38	0.86	H_2O	1.47						
BaO	0.03	0.02								
S	0.17	0.53		99.67						
$H_2O^{-105°}$	0.20									
	99.80									

Quantitative System: III: 6: 4: 4—5 — No name.
Osann's Type: No. 101. Workotsch (s 48, a 3.5, c 2, f 24.5, n 6.7, k 0.67)
Or: Ab: An: Ne — 26.52: 18.82: 34.66: 20.00.
Sp. gravity $\frac{20°}{4°}$ C: 3.043.

Analysis Nr. 31.

Coarse solid Greenstone, bottom part of flow. Hjärpberget, Hill (Ls - 111).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	47.76	79.52	Or	4.46	Hornblende	50.5	qz	−36	s	52.4
TiO_2	1.70	2.12	Ab	32.45	Albite		si	106	A	5.1
P_2O_5	0.46	0.32	An	12.53	($Ab_{92}An_8$)	40.7	ti	2.79	C	2.9
Al_2O_3	12.63	12.39	Ne	2.50	Biotite	4.5	al	16.5	F	31.5
Fe_2O_3	1.78	1.11	Σ sal	51.94	Ores	3.1	fm	59.0	a	4.0
FeO	10.97	15.27	Di	11.31	Apatite	1.0	c	14.0	c	2.0
MnO	0.11	0.16	Ol	27.13	Calcite	0.2	alk	10.5	f	24.0
MgO	10.81	26.81	Mt	2.57			mg	0.60	n	9.0
CaO	5.87	10.47	Ilm	3.21		100.0	k	0.10	k	0.77
Na_2O	4.37	7.05	Ap	1.02			c/fm	0.24		
K_2O	0.77	0.82	Pr	0.22						
$H_2O^{+105°}$	2.07	11.46	Σ fem	45.46						
CO_2	0.06	0.14	H_2O	2.07						
S	0.08	0.25								
				99.47						
$H_2O^{-105°}$	0.08									
	99.52									

Quantitative System: III: 5: 2: 5 — (Rang Kilauase).
Osann's Type: No. 70. Yogo Peak (s 57, a 3.5, c 2, f 24.5, n 5.4, k 0.75).
Or: Ab: An: Ne — 8.59: 62.48: 24.12: 4.81.
Sp. gravity $\frac{20°}{4°}$ C: 2.912.

Analysis Nr. 32.

Fine-grained greenstone at Loos, cross-road to Ljusdal (Ls - v - 429).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	49.42	82.28	Or . .	7.79	Albite		qz	− 22	s	56.5
TiO_2	2.00	2.50	Ab . .	36.69	$(Ab_{93}An_7)$.	39.4	si	126	A	5.7
P_2O_5	tr.	—	An . .	17.52	Hornblende .	38.4	ti	3.83	C	4.2
Al_2O_3	14.99	14.71	Σ sal .	62.00	Ores	12.1	al	22.5	F	23.5
Fe_2O_3	5.71	3.58	Hy . .	5.87	Biotite . . .	10.1	fm	46.5	a	5.0
FeO	8.83	12.29	Di . .	12.59		100.0	c	18.0	c	4.0
MnO	0.40	0.56	Ol . .	5.13			alk	13.0	f	21.0
MgO	4.06	10.07	Mt . .	8.30			mg	0.33	n	8.3
CaO	6.61	11.79	Ilm .	3.80			k	0.17	k	0.86
Na_2O	4.32	6.97	Σ fem	35.69			c/fm	0.39		
K_2O	1.31	1.39	H_2O .	2.06						
$H_2O+105°$	2.06	11.44		99.60						
$H_2O-105°$	0.10									
	99.81									

Quantitative System: II: 5: 3: 4 — *Andose.*
Osann's Type: No. 75. Dignaes (s 55, a 6, c 4, f 20, n 7.7, k 0.80).

Or: Ab: An — 12.56: 59.18: 28.26.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.854.

Analysis Nr. 33.

Effusive Spilitic Greenstone at Loos, main road in front of the Church. (Ls - v - 428.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	55.66	92.67	Q . .	6.37	Albite		qz	− 7.5	s	61.5
TiO_2	1.50	0.88	Or . .	7.26	$(Ab_{92}An_8)$.	43.9	si	154.5	A	6.0
P_2O_5	0.06	0.04	Ab . .	39.85	Hornblende .	25.4	ti	1.57	C	2.9
Al_2O_3	13.72	13.46	An . .	12.80	Quartz . . .	11.6	al	23.5	F	20.6
Fe_2O_3	5.63	3.53	Σ sal .	66.28	Ores	10.3	fm	45.0	a	6.0
FeO	6.95	9.67	Di . .	10.96	Biotite . . .	8.6	c	16.0	c	3.0
MnO	0.20	0.28	Hy . .	11.12	Apatite . . .	0.2	alk	15.5	f	21.0
MgO	3.67	9.10	Mt . .	8.15		100.0	mg	0.35	n	8.5
CaO	5.27	9.40	Ilm .	2.15			k	0.15	k	0.99
Na_2O	4.71	7.60	Σ fem	32.38			c/fm	0.36		
K_2O	1.25	1.33	H_2O .	0.98						
$H_2O+105°$	0.98	5.44		99.64						
$H_2O-105°$	0.13									
	99.73									

Quantitative System: II: 5: 2: 4 — *Akerose.*
Osann's Type: No. 57. Mte Austida (s 59.5, a 6.0, c 4.0, f 20,5, n 6.9, k 0.94).

Or: Ab: An — 12.11: 66.52: 21.37.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.916.

Analysis Nr. 34 a.

Andesinite-dyke at Hjärpberget, Loos (Ls - v - 124).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	56.99	94.89	Ab . . 61.34	Andesine	qz − 8	s 64.3
TiO_2	1.06	1.31	An . . 31.72	($Ab_{68}An_{32}$) . 93.9	si 184	A 8.0
P_2O_5	0.25	0.18	Or . . 1.13	Titanomagnetite 3.4	ti 2.52	C 7.8
Al_2O_3	24.11	23.65	Ne . . 0.29	Chlorite (Sp_1At_1) 1.2	al 46.0	F 2.6
Fe_2O_3	0.88	0.55	C . . 0.20	Muscovite . . 0.9	fm 8.0	a 13.0
FeO	1.64	2.28	Σ sal . 94.68	Apatite . . . 0.6	c 23.0	c 13.0
MnO	0.03	0.04	Ol . . 0.78	100.0	alk 23.0	f 4.0
MgO	0.19	0.47	Mt . . 1.31		mg 0.13	n 9.9
CaO	6.73	12.00	Ilm . 1.99		k 0.02	k 0.97
Na_2O	7.32	11.81	Ap . . 0.59		c/fm 3.08	
K_2O	0.21	0.22	Σ fem 4.67			
$H_2O+{}^{105°}$	0.32	1.78	H_2O . 0.32			
			99.67			
$H_2O-{}^{105°}$	0.07					
	99.80					

Quantitative System: I: 5: 3: 5 — *Loosose* (proposed name).
Osann's Type: No corresponding type (s 64.5, a 13, c 13, f 4, n 9.9, k 0.97).

Or: Ab: An: Ne — 1.19: 64.90: 33.57: 0.34.

Sp. gravity $\frac{20°}{4°}$ C: 2.740.

Analysis Nr. 34 b.

Centre of Andisinite-dyke at Tenskog, Loos.

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	49.04	81.65	Ab . . 52.20	Andesine	qz − 29	s 59.3
TiO_2	4.60	5.76	An . . 27.81	($Ab_{67}An_{33}$) . 79.6	si 141	A 6.9
P_2O_5	0.92	0.65	Or . . 0.59	Titano-magne-	ti 10.04	C 7.1
Al_2O_3	21.15	20.75	C . . 0.71	tite 14.9	al 36.0	F 12.1
Fe_2O_3	3.78	2.37	Σ sal . 81.31	Chlorite (Sp_1At_1) 2.9	fm 25.5	a 8.0
FeO	6.43	8.95	Ol . . 1.50	Apatite . . . 2.1	c 21.0	c 8.0
MnO	0.03	0.04	Mt . . 5.50	Muscovite . . 0.5	alk 17.5	f 14.0
MgO	0.45	1.12	Ilm . 8.77	100.0	mg 0.07	n 9.9
CaO	6.76	12.05	Pr . . 0.33		k 0.01	k 0.88
Na_2O	6.20	10.00	Ap . . 2.07		c/fm 0.21	
K_2O	0.13	0.14	Σ fem 18.17		p 1.21	
$H_2O+{}^{105°}$	0.35	1.94	H_2O . 0.35			
S	0.08	0.25	99.83			
	99.92					
$H_2O-{}^{105°}$	0.16					
	100.08					

Quantitative System: II: 5: 3: 5 — *Beerbachose.*
Osann's Type: No corresponding type (s 59 5, a 8, c 8, f 14, n 9.9, k 0.88).

Or: Ab: An — 0.74: 64.76: 34.50.

Sp. gravity $\frac{20°}{4°}$ C: 3.020.

magnetite-ores at the centre of the andesinitic dykes must be referred to secondary retrogressive differentiation within the dykes.

The differentiation is also accompanied in both cases by a decreasing potassium content and increasing titanium. The Fe_2O_3: FeO ratio moves from 0.54 in the feeding dykes to 0.81 in the spilitic effusives, but attains only 0.53 in the andesinites. There is also a marked difference in the percentage of apatite, which runs to almost nil in the former but increases its concentration in the latter.

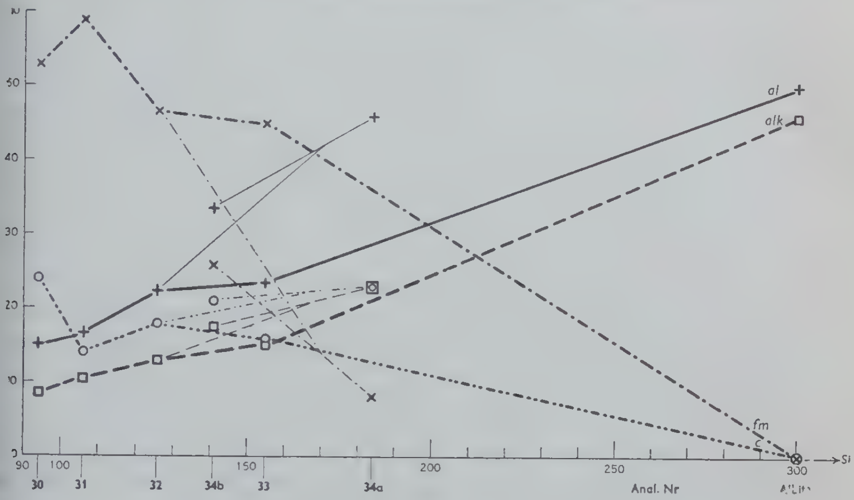


Fig. 9. Niggli diagram of the Loos greenstones.

As shown by the modes, the potassium never occurs as felspathic mineral but always combines into biotite. In the feeding dykes, however, some small relics of orthoclase have been observed, although their percentage is too small to enter into the mode.

Recently the origin of the spilitic rocks has been widely discussed and the different opinions on the subject were admirably summarized by Gilluly (Am. J. Sc. Vol. 1935). If the analyses of the present spilites are plotted together with other Swedish rocks described as spilites in various diagrams, no important differences can be noted. From what has been said about the Loos rocks, the present author must draw the conclusion that the postulation of a special spilitic magma is not warranted by the actual facts. The spilitic character in this case is evidently the result of late magmatic metamorphism within the magma itself, the earlier erupted rocks having, so to say, been »stewed in their own juice». It is not necessary, therefore, either to create any ingenious hypothesis to explain the presence of the albite, or to assume any unusual cause of differentiation within an unknown magma.

Even if the average analyses may show some differences when compared with the analyses of the average metabasalts or basalts, as summarized by FAIRBAIRN in his recent paper on the spilites (8) these differences are rather insignificant. When compared with the basalt, the Loos-greenstones, as well as the metabasalts, as is emphasized by FAIRBAIRN, show an alteration accompanied by loss of total Fe and Na_2O but with a constancy of SiO_2, MgO and CaO. The present author is firmly of the opinion that the Loos-greenstones were originally nothing else but ordinary basalts.

Finally, a few words may be said respecting the metamorphism of the greenstones due to exogeneous influence.

Attention has already been called to the transformation of calcite and quartz into epidote within the vesicles, a feature actually used by the author as a helpful »guiding fossil» when first mapping the boundaries of the greenstones. The influence of the surrounding potassic granites has, too, in the proximity of the contacts, led to a noticeable increase in biotite, not accounted for by the primary potassium content, but due to the passage of solutions from the granite. The thermal metamorphism has also led to the total recrystallization of the felspar lathes into irregular grains, to the increase of hornblende and the total disappearance of pyroxene. At the very contact, however, a diopsidic augite reappears, the temperature rising to the level of retrogressive metamorphism. Within certain areas of the northern part of the greenstones where, in addition to the rise in temperature, a considerable stress must have prevailed connected with the transversal folding of the Loos-syncline, the green hornblende is transformed into antophyllite and even some chlorite, the liberated lime at the same time forming pistazitic epidote.

Where, as along the brecciating fault lines, the greenstones have been subjected to intense shearing stress without rise of temperature, they are generally turned into totally crystallized schistose amphibolites, the earlier radial amphiboles changing into elongated prisms arranged along the planes of schistosity (cf. Pl. XXXIV, Fig. 2). Generally, no epidote is present in those amphibolites. Turning to the tuffitic greenstones, we find their autogeneous and exogeneous metamorphism similar to that of the solid rocks. Obviously, however, they have in places not been subjected to the influence of the late magmatic albitic solutions; this, for instance, is the case at the Orrekullen Hill S. of Risberg, from which analysis No. 35 has been prepared.

Analysis Nr. 35.

Tuffitic Greenstone, south-western slope of Orrekullen Hill (Ls - 451).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	52.69	87.73	Q	0.66	Plagioclase	30.8	qz	—11	s	56.0
TiO_2	1.80	2.25	Or	3.85	$(Ab_{76}\ An_{24})$*)		si	123	A	3.7
P_2O_5	0.20	0.14	Ab	27.77	Pyroxene	24.5	ti	3.16	C	3.8
Al_2O_3	12.31	12.08	An	16.97	Hornblende	19.2	al	17.0	F	29.2
Fe_2O_3	3.47	2.17	Σsal	49.25	Biotite	10.6	fm	50.5	a	3.0
FeO	6.93	9.65	Hy	17.41	Ores	8.5	c	24.0	c	3.0
MnO	0.10	0.14	Di	24.45	Quartz	6.0	alk	8.5	f	24.0
MgO	8.89	22.05	Mt	5.05	Apatite	0.4	mg	0.65	n	8.9
CaO	9.77	17.42	Ilm	3.45		100.0	k	0.12	k	0.95
Na_2O	3.27	5.28	Ap	0.38			c/fm	0.48		
K_2O	0.62	0.66	Σfem	50.74	*) Average composition.					
H_2O +105°	0.18	1.00	H_2O	0.18						
				100.17						
H_2O—105°	0.07									
	100.30									

Quantitative System: III: 5: 3: 5 — *Ornose.*
Osann's Type: No 76. Gerstenberg (s 52.5, a 3.5, c 4, f 22.5, n 7.7, k 0.80).
Or: Ab: An — 7.95: 57.15: 34.90.
Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.940.

The mode in this case shows an average of more basic felspar, and a pigeonitic pyroxene is largely preserved. The optic characteristics of this latter mineral:

$$2V_{550} = 42^\circ;\ c/_\gamma = 37.5^\circ;\ (\gamma - \alpha)_{550} = 0.031$$

clearly indicate a composition corresponding to the mineral of the solid magma. The biotite, too, is of the same greenish colour, and the habit of the hornblende indicates a partly advanced metamorphism, which, however, may have been increased subsequently to the emplacement of the tuffite by the folding of the syncline and the thermal influence of the adjoining Risberg granite.

At some places, the tuffitic greenstones have been subjected to an intense metamorphism, both dynamically and thermally, completely changing their mineral constituents and obliterating all primary features except the presence of ilmenite, which latter may still be seen as streaks of grains along the planes of schistosity. Two examples may be taken as representing the two main varieties — the tuffitic schists between Lakes Dåasen and Sättnässjön, and the tuffites S. of Rullbo.

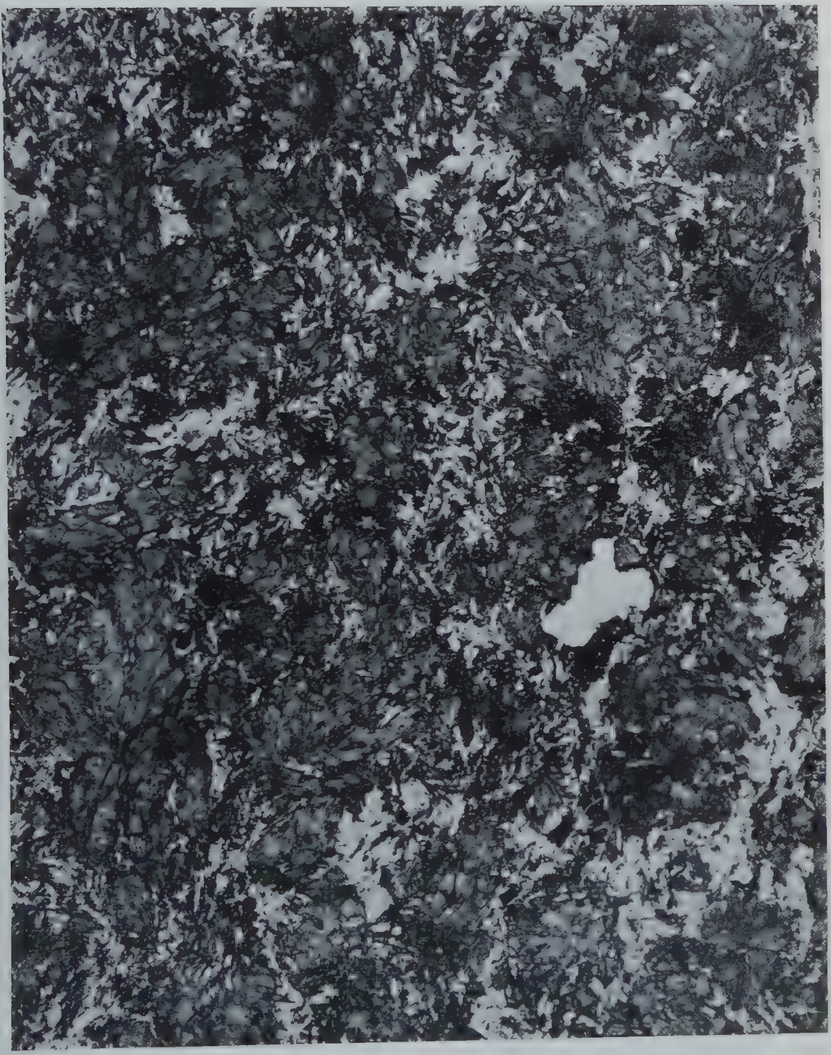
The present »mise en place» of the former rocks is rather involved. Having been deposited horizontally or on the slopes of the volcanoes of those days, the tuffs must have partaken in the first N.S. synclinal foldings of the Loos-field and may even have been thermally altered by the regional rise in temperature following the intrusion of the granite of the Dåasen Hill. If the writer's conception of the tectonics is accurate, however, they were not in direct contact with this granite, the close proximity to the granite of to-day resulting from their displacement southwards at the time of the Rätan intrusion, when the northern part of the syncline was crushed from the N. and folded at right angles into a new E.W. syncline.

The tuffs were then squeezed between the older rocks to the S. and the advancing Rätan granite from the N., and at the same time obviously subjected to a considerable rise in temperature, accompanied on the N. side by an accession of volatiles from the magma. As set forth in more detail in the following chapter, the Rätan granite, it is true, seems remarkably »dead» along its contacts, and is made conspicuous by the almost total absence of accompanying pegmatites. Nevertheless, a notable metasomatic metamorphism is observable along the northern contact towards the tuffitic schists, even if it penetrates only to a moderate depth.

The southern half of the schists are true amphibolites. Green prismatic hornblende is a predominating mineral, forming about 60—70 % of the rock, the balance being made up of nicely twinned andesinic felspar, some quartz, titanite and titano-magnetite. The hornblende is optically negative $^{c}/_{\gamma} = 19°$, and has an axial angle of $2V_{550} = 79.5°$. It is of a deep green colour. The titanite and titano-magnetite occur, true enough, in strings following the direction of the elongation of the hornblende, but a local increase in quantity is noticeable in zones at an oblique angle to the strike, which may, or may not, indicate the original planes of sedimentation.

Crossing the amphibolite schists towards the Dåasen granite, the oriented texture gradually grows less distinct and the rock merges into a typical hornfels, a brownish biotite simultaneously entering the composition and distinctly replacing the hornblende. Finally, the hornblende disappears completely and the rock is changed into a dense grayish, brown hornfels, with bluish-black elliptical or circular spots of resinous lustre on fractured surfaces, which, in thin section, are seen to be poeciloblastic cordierites. These stand out on weathered surfaces as 1—2 cm-long ellipsoids, making the rock distinctly knotty and reminding one of a miniature conglomerate.

The mineral constituents in addition to the cordierites are: biotite, some antophyllitic amphibole, quartz, and a little ilminite and magnetite. The plagioclase and the titanite have disappeared. No chemical



Solid greenstone from bottom portion of a flow at Hjärpberget. Secondary actinolitic hornblende (light gray) developing as radiating »brushes». White areas are albite. Ord. ligh. Magnif. × 10.

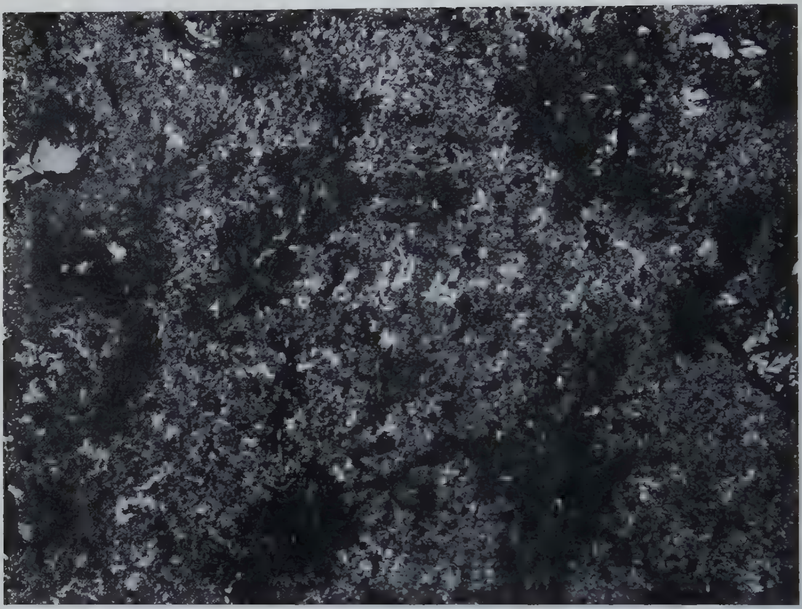


Fig. 1. Advanced metamorphism of greenstone. Developing of secondary green biotite (dark spots). Light gray is hornblende. Ord. light. Magnif. × 12.

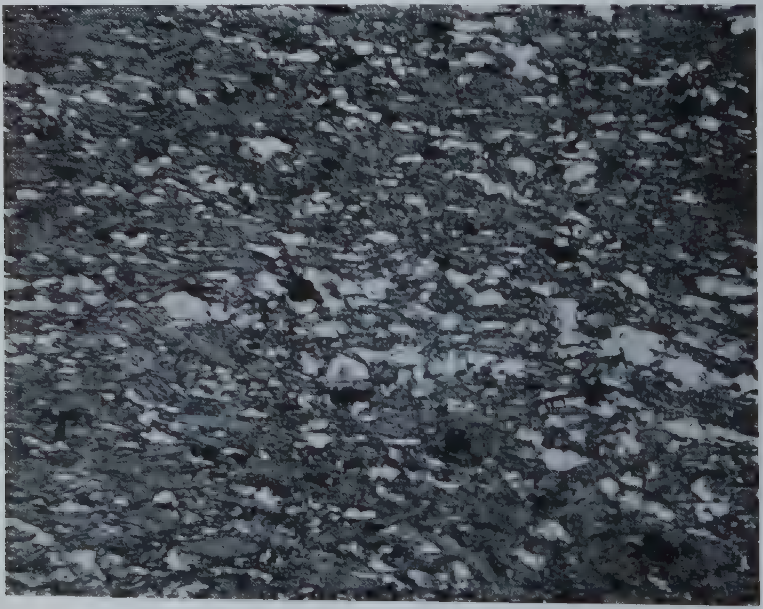
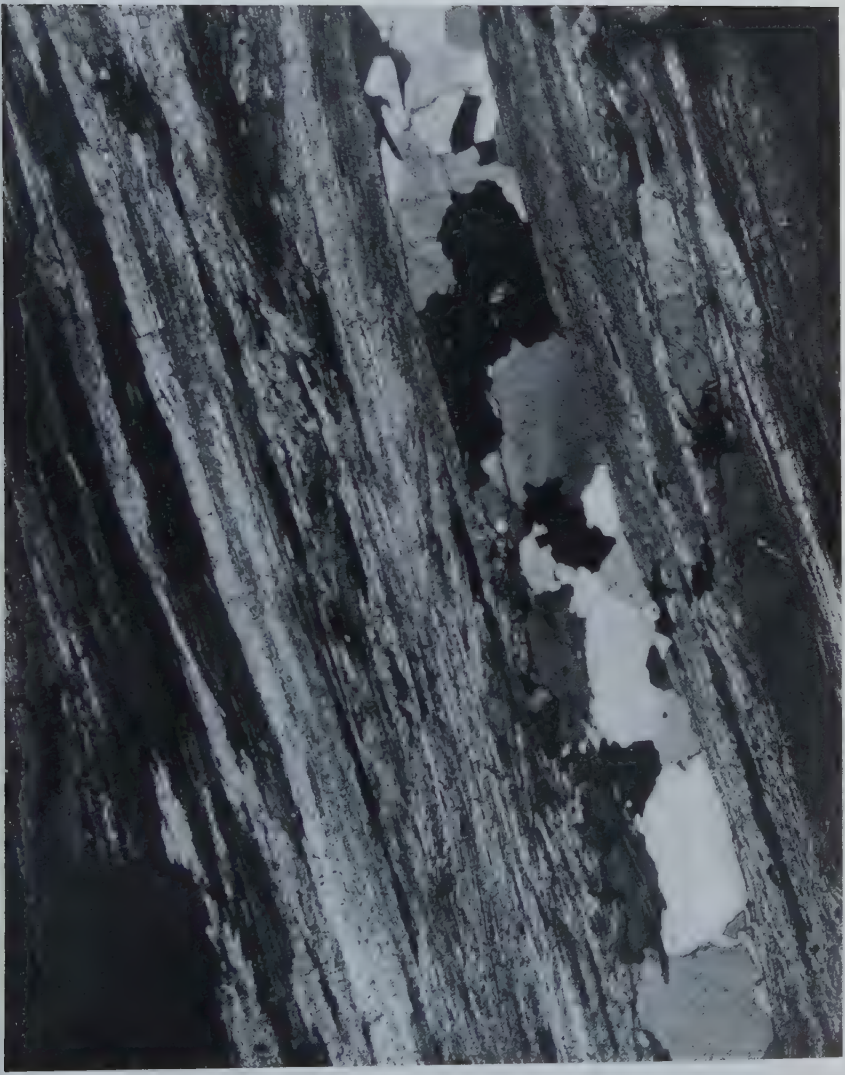


Fig. 2. Greenstone, completely metamorphosed into amphibolite. Ord. light. Magnif. × 12.



Grünerite in greenstone. Southern fault at Hjärpberget. Nic. +. Magnif. × 40.

Fig. 1. Totally re-crystallized amphibolitic greenstone at the contact towards the Rätan granite at Öjungshammaren. Ord. light. Magnif. × 8.

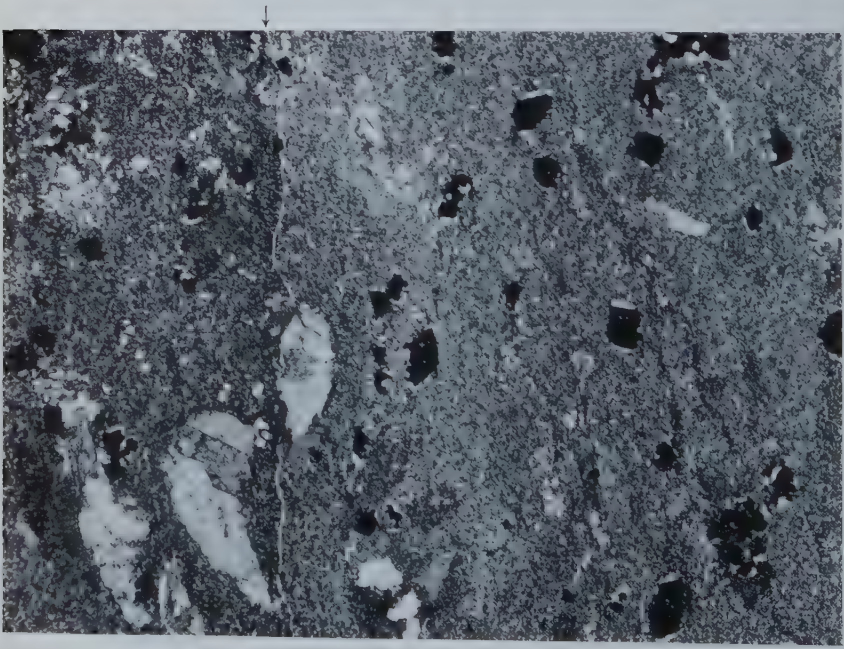


Fig. 2. Contact (arrow) between greenstone to the left and quartz-porphyry to the right, NE of Risberget. The porphyry is contaminated by pyrite (black) absorbed from the greenstone. Ord. light. Magnif. × 10.

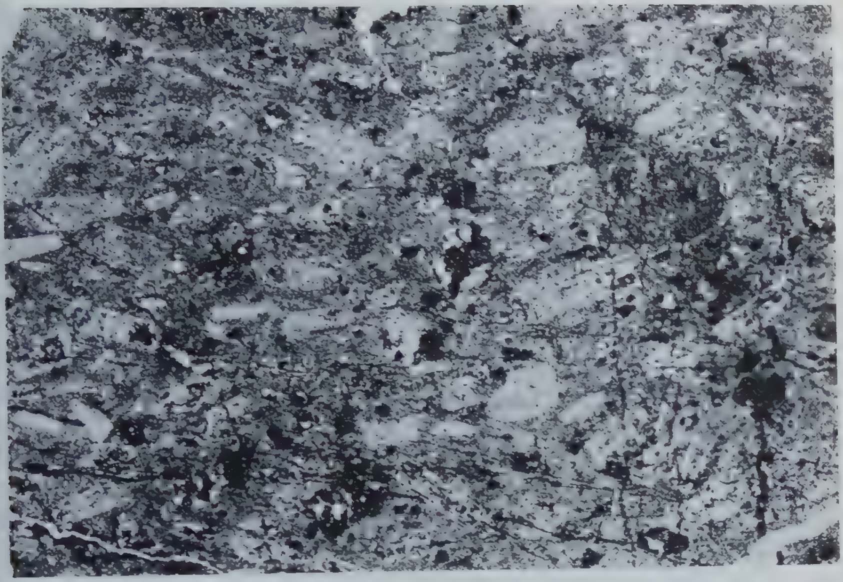


Fig. 1. Keratophyric pebble in greenstone agglomerate from N. Hocklan. The rock is not found in solid outcrop. Ord. light. Magnif. × 10.

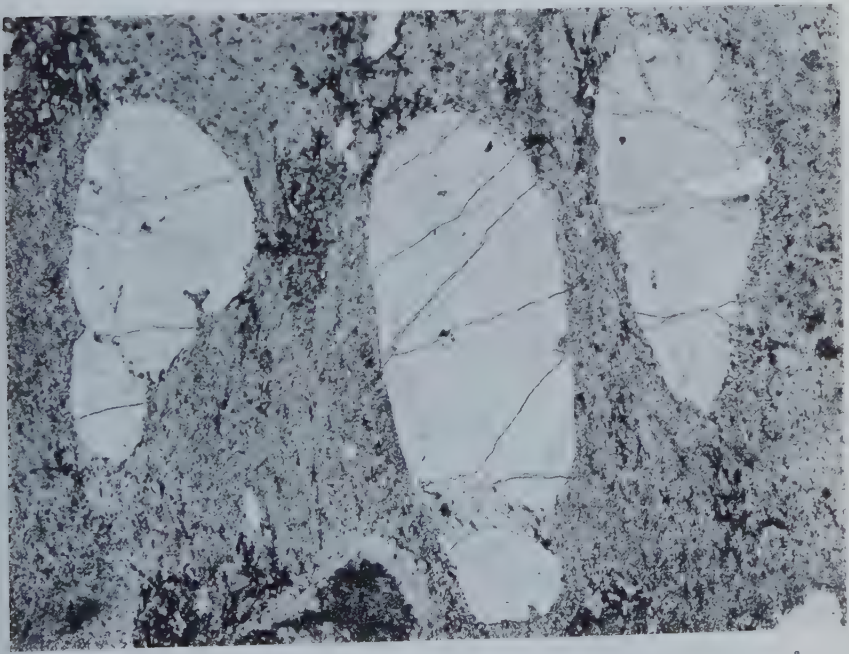


Fig. 2. Effusive, thermally metamorphosed Loos quartz-porphyry from Risberget. Three vesicles filled with quartz. The dark spots of the base are biotite. Ord. light. Magnif. × 10.

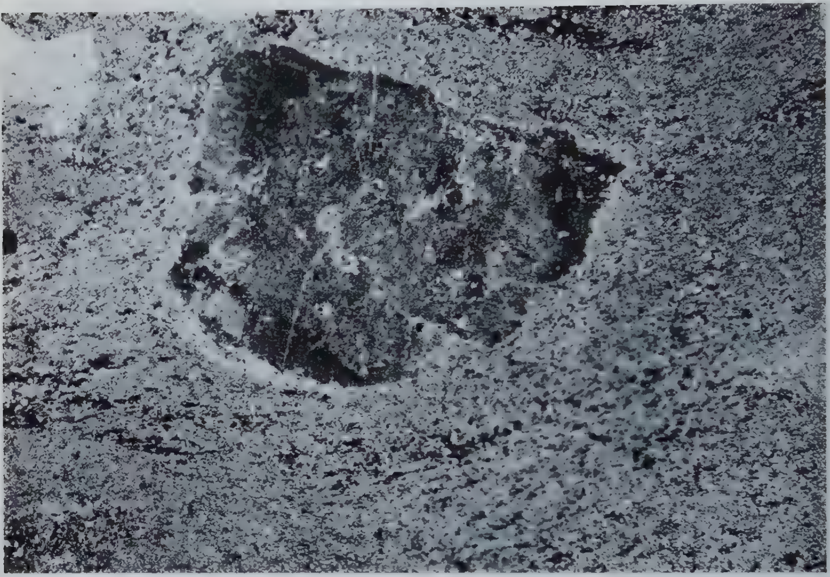


Fig. 1. Microcline phenocrysts in effusive Loos quartz-porphyry, Risberget. Ord. light. Magnif. × 10.

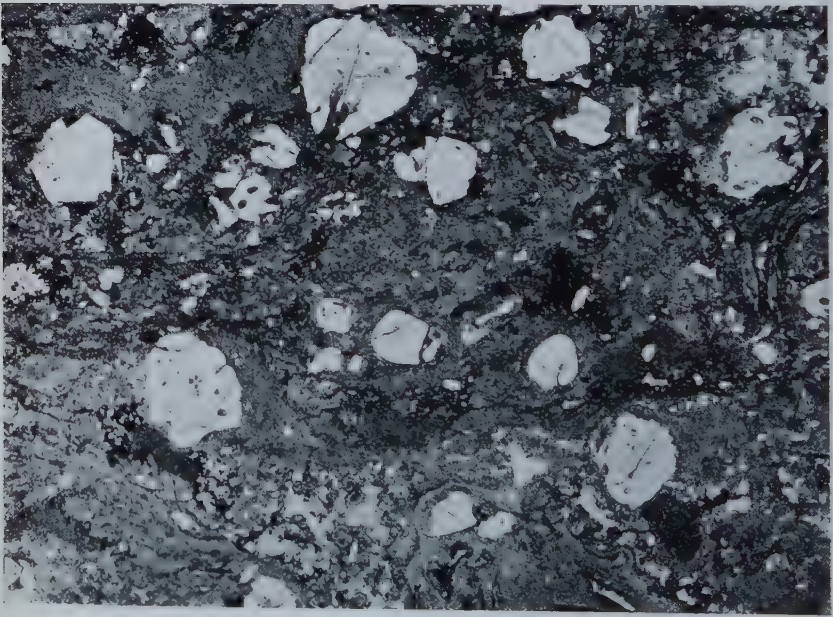
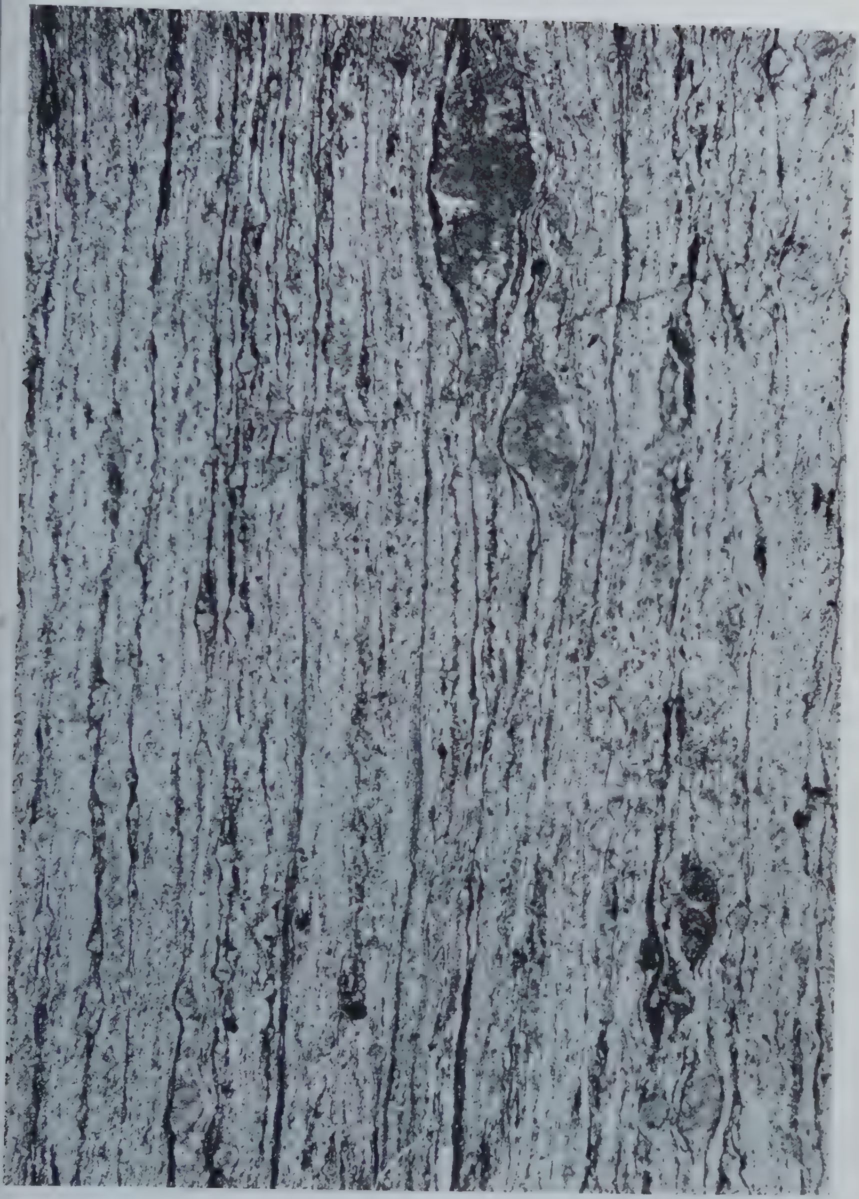


Fig. 2. Loos quartz porphyry from a small lake, SW of Öratjärn N of Woxna Hed. Primary fluidal textures are still preserved. Groundmass is rich in biotite. Ord. light. Magnif. × 10.



Mylonitized Loos quartz-porphyry at Toberget. Ord. light. Magnif. × 10.

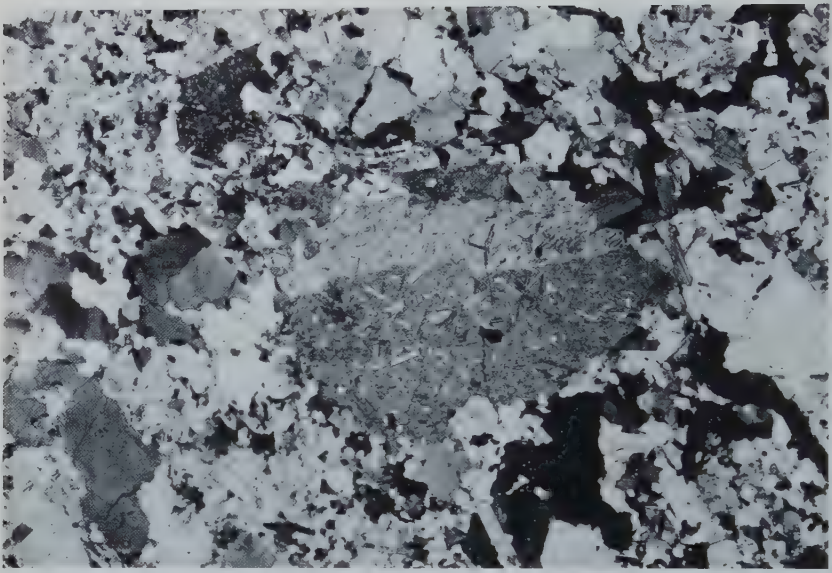


Fig. 1. Dåasen granite from the hill S of Långtjärn. The twinned microcline phenocryst is filled with oriented sericite. Nic. +. Magnif. × 10.

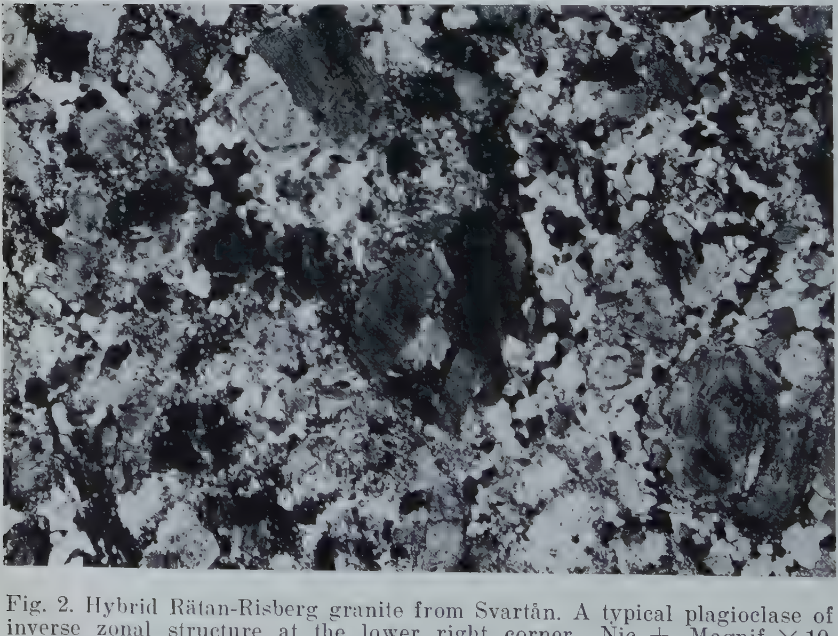


Fig. 2. Hybrid Rätan-Risberg granite from Svartån. A typical plagioclase of inverse zonal structure at the lower right corner. Nic. +. Magnif. × 10.

analysis of this rock has been made, but a removal of lime as well as soda from the amphibolite is obvious.

The metamorphism of the schists is almost identical with that described by Tilley as associated with the greenstone hornfelses of Cornwall (35). Only the transitory cummingtonite-antophyllite-plagioclase phases of his metamorphic sequence are mostly absent. The actual contact with the granite is not exposed but, a short distance away, the ordinarily pink granite exhibits a gray marginal phase enriched with sodic plagioclase. The chemical changes brought about at the contact may, therefore, be considered as partly an interchange of alkalies, lime and silica, — the potassium and silica of the granite having passed into the greenstone schists, thus resulting in the formation of biotite and the lime and soda of the latter having migrated into the granite — and partly as an internal magnesia-metasomatism resulting in the magnesia and alumina, which have been set free by the decomposition of plagioclase and hornblende, combining into cordierite. Some of the alumina obviously enters the biotite, which latter may retain a minor portion of the soda, too.

Turning to the exceedingly fine-grained, almost dense tuffitic schists S. of Rullbo — probably originally ashes — their present metamorphic state is somewhat different. Cordierite is totally absent, and the mineral constituents of the strongly schistose and foliated tuffs are, mainly, brownish biotite, sericite, albitic plagioclase and quartz. Within zones of intense shearing stress, large roughly rectangular dark green poeciloblastic chloritoides are scattered through the rock (cf. Pl. L), giving it megascopically a spotted appearance. Numerous streaks of small ilmenite and magnetite grains are always present.

Only occasionally are there found zones where the »original» hornblende still remains, mostly transformed, however, into cummingtonite. The potash-felspar is conspicuously absent, although in many cases one would have expected it to have been formed by a retrogressive metamorphism at the advanced stage of metamorphism here represented.

On the other hand, the tuffitic phyllites farther S.E. of Rullbo at the river V. Håcklan bear witness to a decided relaxation of shearing stress at some later period of their metamorphism, as is clearly emphasized by the occurrence of andalusite in irregular spots. Theoretically, it is true, this andalusite may also have originated by contact metamorphism due to the not very distant Risberg-granite, but the fairly restricted andalusite-bearing strata do not show any conformity with the granite contacts. Where the Risberg granite (or maybe also offshoots from the Rätan-granite) have intruded the corresponding tuffites S. of Rullbo, no andalusite is found within the vicinity, and in that case the only noticable metamorphism is an increase of muscovite and the accession of felspathic material.

On the other hand, the proximity of the Risberg granite, rich in volatiles, must have had a considerable influence on the tuffitic sediments as a whole, as evidenced by the fairly common occurrence of tourmaline; the granite being certainly largely responsible for the loss in lime and the disappearance of the amphiboles prior to the intense folding of the tuffs. The remaining amphibolitic character of certain layers here and there speak for a permeation by the volatile granitic solutions along the more porous bedding planes, leaving the more solid unaffected.

Turning farther N. along the V. Håcklan river, a somewhat different metamorphic picture is presented by the tuffs adjoining the small area of greenstones exposed within the late Loosian slates N. of the road to Loos. Partly they correspond to the metamorphic grade of their parent greenstones, but, in some small outcrops at their northern boundary there has arisen a deviating and interesting cross-breed between the Rullbo and Dåasen tuffites.

The mineral constituents of the main type of this latter rock are: a dirty-brown biotite, sericitic mica, albitic plagioclase and innumerable grains of titanic ores, constituting a ground mass within which the previously mentioned dark green porphyroblastic chloritoides are scattered. Amphibole is almost totally absent. Within this rock, however, large patches occur where a highly sieve-structured andalusite occupies about 70 % of the area. Within this there are scattered spots of a more or less radially arranged concentric mineral crystallisation around cores of cordierite. The central cordierite is, in many cases, a nicely pseudo-hexagonal twin surrounded by a thin fringe of light green chlorite. Outside the chlorite there is a shell of minute flakes of sericite, succeeded by radial dark green chlorite. In its turn this ferrous chlorite is followed by a new aurole of somewhat larger flakes of sericite, surrounded by brown biotite and, finally, the whole »nest» is separated from the surrounding andalusite by a zone of quartz (cf. Fig. 10).

I shall not attempt in this connection to give an explanation of this peculiar metamorphism within the regional metamorphism of the parent rock, as this will be made the subject of a special study, but I may suggest the possibility that the andalusite patches represent primary agglomeratic inclusions of different chemical composition within the tuffitic sedimentation, derived, maybe from older rocks, maybe from differentiation members of the greenstone magma itself.

The metamorphic agent should be looked for in the Rätan granite to the N.

Finally, the presence of a large content of potassic mica within the tuffites, even at an advanced grade of metamorphism, is worth emphasizing, as it confirms Tilley's suggestion (Min. Mag. Vol. XXI, 1920) of this being the normal course in the presence of a sufficiency of water. The general case of orthoclase taking the place of the dwindling and disappearing muscovite with advancing metamorphism, as stated by Harker, certainly does not apply to the Loos tuffites.

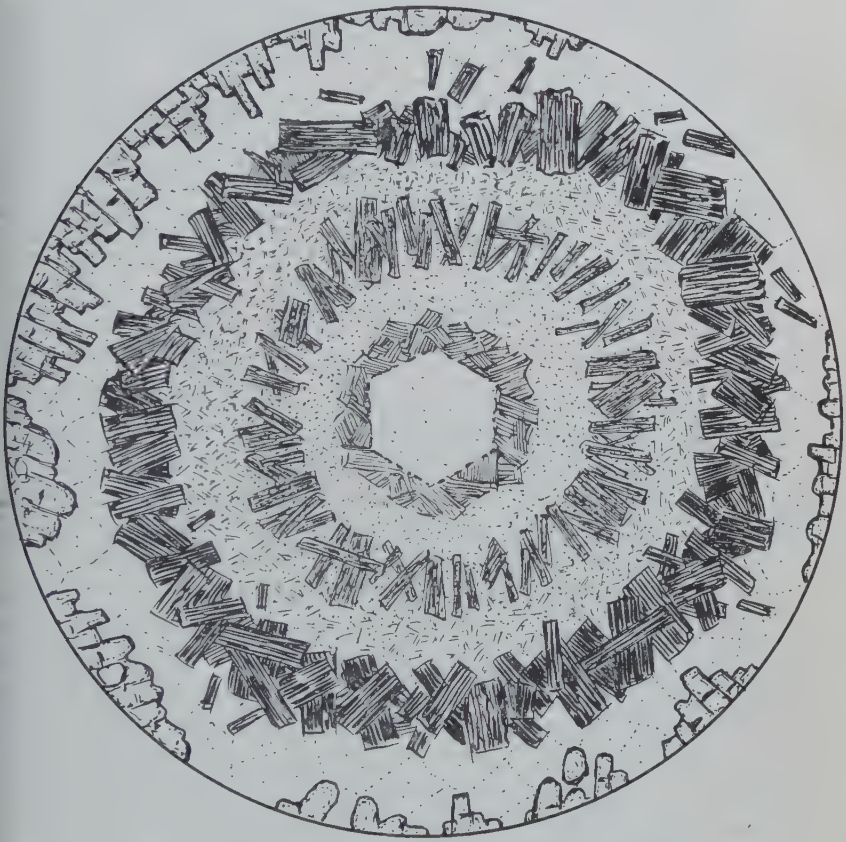


Fig. 10. Concentric metamorphism within Loos tuffite.
(Centre)—Cordierite—Light-green Chlorite—Sericite—Darkgreen Chlorite—Sericite—Brown Biotite—Quartz—Andalusite (Rim). Magnification 20 diam.

The Loos Porphyry.

The greenstone is overlain, without any intermediate sediments except pyroclastic tuffites and agglomerates, by lava flows of a pronounced potassic quartz porphyry, which in the highest hilltop, S.W. of Loos, grades into flows of more intermediary sodic-potassic porphyry. There also occur distinctly amydaloid effusive types of quartz prophyry, with vesicles filled with quartz of a characteristic blue opalisation. This quartz has been used when tracing the sediments arising from the breaking down of the old prophyry area.

At the small porphyry area around Hjärpberget the following descending stratigraphic succession is exposed.

Youngest:	Porphyry-tuff.
	Effusive porphyry.
	Quartz-porphyry.
Oldest:	Agglomerate.

The agglomerate rests on a highly epidotized greenstone (the usual sign of a thermal contact metamorphism) and consists of fragments of greenstone within a matrix of quartz porphyry. The succeeding gray quartz porphyry and dark gray effusive porphyry are the bottom and top parts respectively of the same flow, on top of which the acid tuffs have been deposited later on.

At Gullmyrberget Hill, W. of Loos, a reddish-brown porphyry occupies the very peaks of the ridge, obviously being the remains of an earlier, more extended, lava flow extruded at that level. The porphyry is superimposed on an older flow of gray quartz porphyry, but in this case no agglomerate separates the base of the latter porphyry and the top of the greenstones, although the usual strong thermal metamorphism expressed in the epidotisation of the greenstones is present.

To the N.W. and W. of the ridge, at lower topographic levels, there alternate quartz porphyry and white felsitic tuffs (cf. analyses No. 40). The same succession is observed N.W. of Loos, at Ryggskog. Bordering on the greenstone to the E., dense gray quartz porphyries grade towards the W. into red felspatic porphyries underlying the Loos-quartzite at Ryggskog. Another small area of brown porphyry is exposed immediately to the E. of Losberg Cottage, in a disused gravel quarry, and may represent the neck of an old feeding channel or a sill, rather than a flow. It extends southwards following the base of the greenstone and is separated from the top conglomerate of the sub-Loosian schists by a thin layer of greenstone tuff. This contact was studied by the author N.E. of Aborrtjärn where pits were dug down thorugh the morraine. A fairly strong thermal metamorphism undoubtedly connected with the intrusion of the porphyry was observed within the tuffs.

Farther southwards, S. of Karlsberg and N. of Tennskog, occur two outcrops of a grayish somewhat porphyric rock, which was first taken to be an old metamorphic porphyry within the sub-Loosian series, and, still farther S., N.E. of Mansjö, another isolated outcrop of a highly effusive type of the same porphyry was temporarily exposed during road-work. Numerous boulders of this latter porphyry may be examined along the bye-road leading down to the Mansjö Cottage. This porphyry lies, so to say, along the strike of the Losberg porphyry and has the same character of a fairly narrow, elongated body.

Further study of the metamorphism of the porphyry caused by the Risberg granite and the laboratory examination of the slides has led the author to desert his earlier theory and to regard this gray porphyry as a sill of the Loos series thermally metamorphosed in connection with the intrusion of the said granite, and also strongly subjected to dynamic influence at the synclinal folding of the district.

At Risberg Hill, where the granite comes into direct contact with the effusive porphyry at a number of beautiful exposures, the thermometamorphism in question has been proved to be one of rather local extension affecting the porphyry to a limited depth of a hundred yards or so. This has led the author to assume a close proximity of the Risberg granite also along the E. boundary of the porphyry-sill. The corresponding mapping, however, is not substantiated by any actually observed outcrops. This is clearly shown on the map. The presence of any larger body of younger granites below the porphyries must be ruled out as, if any existed, the old migmatites S. of Tennskog could, in such a case, hardly have escaped being turned into hornfelses, or being otherwise locally metamorphosed.

As shown by the map, well-preserved lenticular sills or feeding dykes of porphyry are also exposed at several other places within the greenstones. Sometimes they exhibit chilled marginal borders towards the greenstone, sometimes, not, from which observation it may be inferred that the extrusion followed immediately on that of the greenstone, while the latter was still hot in places.

The quartz porphyry N. and N.W. of Risberg seems to have partly ntruded between older tuffitic beds or flows of greenstone, their contacts having chemically absorbed material from the greenstone even to the extent of the quartz phenocrysts and vesicles being filled with pyrites, while the average porphyry, in striking contrast with the greenstones, hardly carries any pyritic minerals whatever.

The ore-concentrations within the greenstones, all being situated some 100—500 m. E. of the porphyry contact itself, indicate a prolonged late-magmatic circulation of albitic and hydrothermal solutions in these marginal parts of the greenstone, and may have constituted a zone of weakness along which the major part of the porphyry has erupted.

Even if it is firmly established that the main greenstone extrusion preceded the acid lavas, the author has been in doubt in some cases, however, whether an alternation may not have taken place. Between Tallberget and Tennsberg Hills, for instance, there are found numbers of tuffitic boulders displaying an alternating banding of acid and basic tuffs. This banding may, of course, result from resedimentation by torrential rains during the volcanic period. The absence of any andesenite dykes or late albitic differentiates within the porphyries also speaks against two separate acid eruption periods.

The range of chemical composition among the porphyries is elucidated by the appended analyses No. 36 and 37, which indicate an originally liparitic to andesitic lava. The mineral composition actually observed is given in the mode where, however, the composition of the felspars is given as a calculated average. Actually, the plagioclase-phenocrysts are generally somewhat more basic, about 2—6 %, than the plagioclase of the ground mass.

The decidedly sodic porphyry contains an albitic plagioclase, sometimes displaying periclinal twinning, while the potassic quartz-porphyries run into andesinic felspars. Quartz-phenocrysts occur in both rocks, but are obviously predominant in the quartz-porphyry. They are of a strongly undulous extinction, although, megascopically, the rocks do not appear dynamically affected. Their partaking in the folding of the Loos-synclines is, however, also emphasized by the broken plagioclase phenocrysts, which are tabular in the quartz-porphyries and often lath shaped in the porphyry. The broken pieces are joined together by a secondary green chlorite.

The plagioclases are sometimes also protoclastically brecciated by the ground mass itself and sometimes very much corroded The orthoclase is represented only as strongly corroded phenocryst relics, the bulk of the potash-felspar probably remaining in the ground mass as microcline. The ground mass itself, composed of the two felspars, quartz, and some sericitic mica, is granular and pigmented by titanomagnetite (cf. Pl. XXXVIII).

Occasionally, ore grains are surrounded by shells of secondary titanite. Fairly coarse granophyric textures are also observed around some of the plagioclase-phenocrysts.

Analysis Nr. 36.

Porphyry from the top of Gullmyrberget Hill (Ls - 364).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	70.71	117.73	Q . .	24.98	Albite	43.0	qz	+97	s	77
TiO_2	0.50	0.62	Or . .	26.19	(Ab_{93} An_7)		si	339	A	8.0
P_2O_5	0.28	0.20	Ab .	39.28	Quartz . . .	27.5	ti	1.72	C	0.2
Al_2O_3	12.77	12.52	An .	0.84	Microcline and		al	36	F	6.3
Fe_2O_3	3.35	2.10	Σ sal	91.29	Orthoclase .	14.9	fm	22.5	a	16.5
FeO	1.60	2.23	Di . .	2.18	Mica (chlorite)	9.3	c	6.0	c	0.5
MnO	0.02	0.02	Hy .	0.30	Ores (Ti-magne-		alk	35.5	f	13.0
MgO	0.54	1.34	Mt . .	3.70	tite) . . .	4.6	mg	0.17	n	6.1
CaO	1.14	2.03	Hm .	0.79	Apatite . . .	0.7	k	0.39	k	1.41
Na_2O	4.62	7.48	Ilm .	0.93		100.0	c/fm	0.26		
K_2O	4.47	4.74	Ap .	0.68						
$H_2O + ^{105°}$	0.32	1.80	Σ fem	8.58						
			H_2O .	0.38						
				100.25						
$H_2O - ^{105°}$	0.16									
	100.48									

Quantitative System: I: 4: 1: 3 — *Liparose.*
Osann's Type: No 4. Cantina Ziton (s 78, a 18, c 0, f 12, n 6.2, k 1.23).

Or: Ab: An — 39.63: 59.24: 1.13.

Sp. gravity $\frac{20°}{4°}$ C: 2.670.

Analysis Nr 37.

Quartz-porphyry from Lappmyrberget Hill (Ls - 780 a).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	71.54	119.11	Q . .	38.50	Quartz . . .	35.4	qz	+178	s	77.5
TiO_2	0.48	0.60	Or . .	29.37	Sericitic Mica	20.0	si	374	A	6.5
P_2O_5	0.12	0.08	Ab .	12.59	Orthoclase . .	19.5	ti	1.90	C	2.1
Al_2O_3	13.48	13.22	An .	8.08	Plagioclase .	20.8	al	41.5	F	5.1
Fe^2O_3	2.13	1.33	C . .	2.65	(Ab_{62} An_{38})		fm	24.5	a	14.5
FeO	2.32	3.23	Σ sal .	91.19	Ores	4.0	c	10.0	c	4.5
MnO	0.05	0.07	Hy .	3·61	Apatite . . .	0.3	alk	24.0	f	11.0
MgO	0.72	1.79	Mt . .	3.05		100.0	mg	0.23	n	4.4
CaO	1.79	3.19	Ilm .	0.96			k	0.69	k	1.64
Na_2O	1.49	2.40	Ap .	0.28			c/fm	0.41		
K_2O	4.99	5.30	Σ fem	7.90						
$H_2O + ^{105°}$	0.65	3.61	H_2O .	0.65						
				99.74						
$H_2O - ^{105°}$	0.14									
	99.90									

Quantitative System: I: 3: 2: 2 — *Mihalose.*
Osann's Type: No 22. Llao Roch (s 78, a 17, c 5.5, f 7.5, n 6.4, k 1.54).

Or: Ab: An — 58.69: 25.16: 16.15.

Sp. gravity $\frac{20°}{4°}$ C: 2.670.

Analysis Nr. 38.

Metamorphosed Effusive Porphyry at road south of Loos (Ls - 765).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	74.00	123.21	Q . .	37.95	Quartz . .	38.1	qz	+202	s	79.5
TiO_2	0.40	0.63	Or . .	30.76	Orthoclase . .	26.8	si	424	A	7.1
P_2O_5	0.10	0.07	Ab .	17.77	(Microcline)		ti	2.06	C	1.0
Al_2O_3	12.70	12.46	An .	3.65	Plagioclase .	21.5	al	430	F	4.1
Fe_2O_3	0.97	0.61	C . .	2.33	(Ab_{85} An_{15})		fm	21.5	a	17.5
FeO	2.01	2.80	Σ sal .	92.46	Biotite . . .	7.1	c	5.0	c	2.5
MnO	0.04	0.06	Hy .	4.50	Muscovite . .	4.0	alk	30.5	f	10.0
MgO	0.91	2.26	Mt . .	1.40	Ores	2.2	mg	0.35	n	3.8
CaO	0.92	1.64	Ilm .	0.83	Apatite . . .	0.3	k	0.62	k	1.64
Na_2O	2.08	3.36	Ap .	0.25		100.0	c/fm	0.25		
K_2O	5.18	5.50	Σ fem	6.98						
$H_2O + 105°$	0.35	1.94	H_2O .	0.35						
				99.79						
$H_2O - 105°$	0.13									
	99.79									

Quantitative System: I: 3: 2: 3 — *Tehamose.*

Osann's Type: No 9. Kiirunavaara (s 78.5, a 17.0, c 1.5, f 11.5, n 5.7, k 1.50)

Or: Ab: An — 58.95: 34.05: 7.00.

Sp. gravity $\frac{20°}{4°}$ C: 2.685.

Analysis Nr. 39.

Contact-metamorphosed Quartz-Porphyry, 130 meters above the N.E corner of the claim of the old Risberg Iron Mine (Ls - 675).

Analyst: N. Sahlbom.

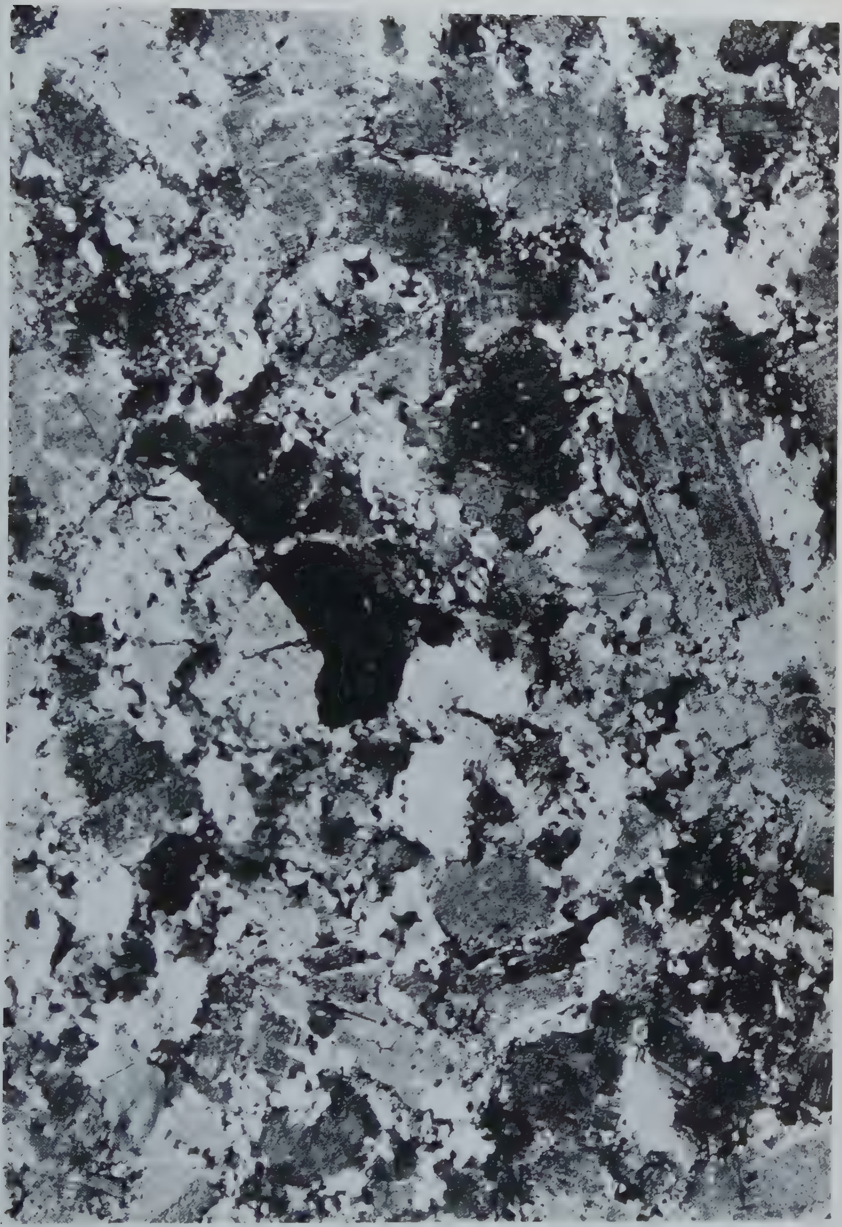
	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	73.82	122.91	Q . .	38.92	Quartz . . .	54.7	qz +	211	s	80
TiO_2	0.26	0.41	Or . .	43.09	Muscovite . .	29.4	si	437	A	7.3
P_2O_5	0.15	0.11	Ab .	7.35	Albite	7.3	ti	1.42	C	0.5
Al_2O_3	12.32	12.09	An .	1.10	Biotite . . .	4.7	al	43.0	F	4.3
Fe_2O_3	2.09	1.31	C . .	2.65	Ores (some titanite) . . .	3.5	fm	23.0	a	18.0
FeO	1.58	2.20	Σ sal .	93.11	Apatite . . .	0.4	c	2.5	c	1.5
MnO	0.04	0.06	Hy .	2.45		100.0	alk	31.5	f	10.5
MgO	0.67	1.66	Mt . .	3.02			mg	0.26	n	1.5
CaO	0.38	0.68	Ilm .	0.55			k	0.85	k	1.62
Na_2O	0.88	1.42	Ap . .	0.32			c/fm	0.11		
K_2O	7.25	7.70	Σ fem	6.34						
$H_2O + 105°$	0.70	3.89	H_2O .	0.70						
				100.15						
$H_2O - 105°$	0.17									
	100.31									

Quantitative System: I: 3: 1: 2 — *Magdeburgose.*

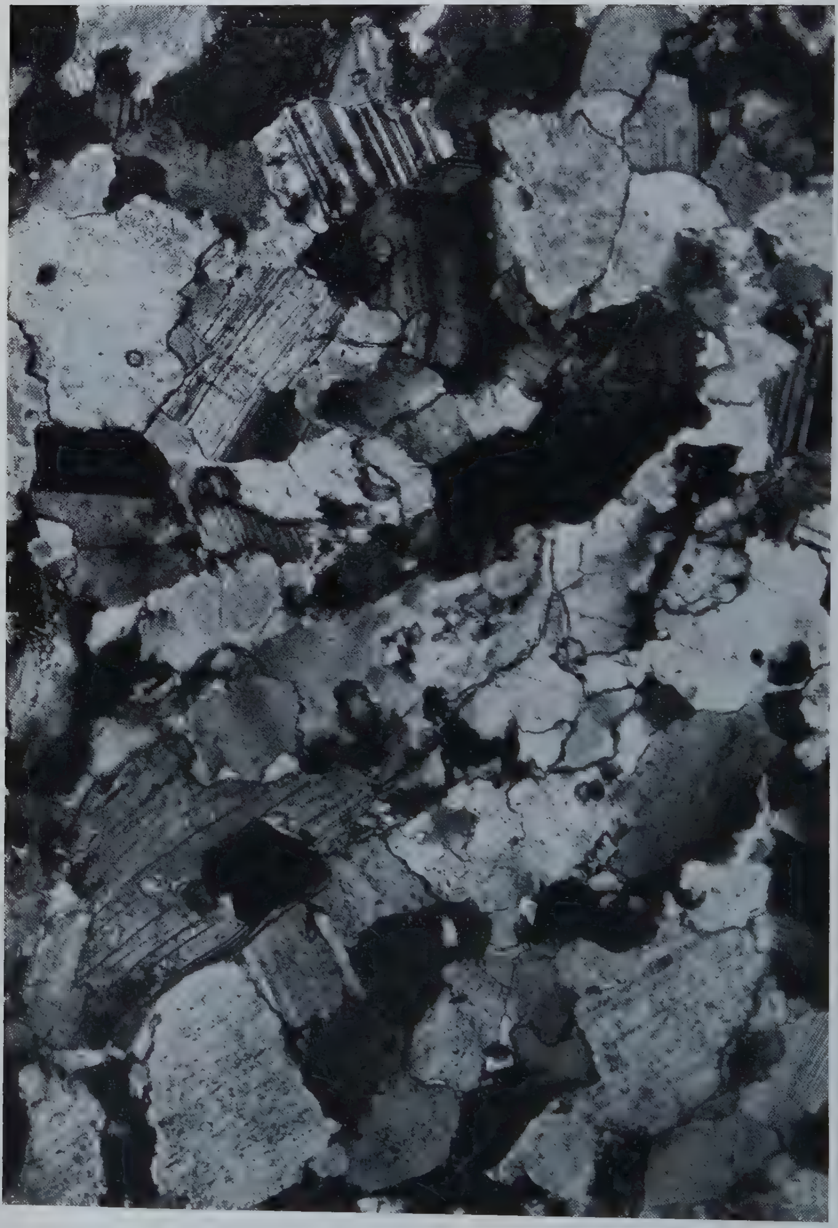
Osann's Type: No 9. Kiirunavaara (s 78.5, a 17, c 1.5, f 11.5, n 5.7, k 1.50).

Or: Ab: An — 83.60: 14:26: 2.14.

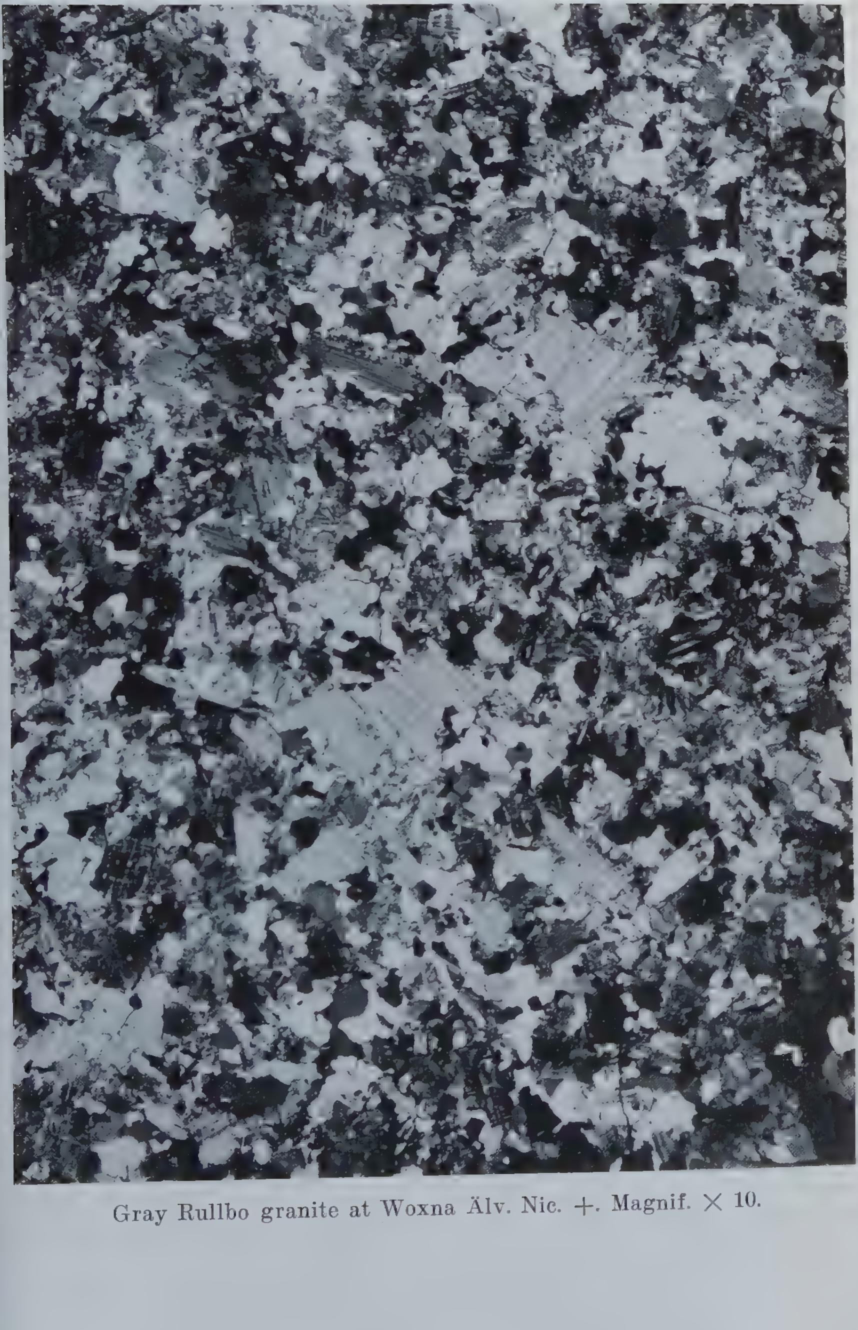
Sp. gravity $\frac{20°}{4°}$ C: 2.671.



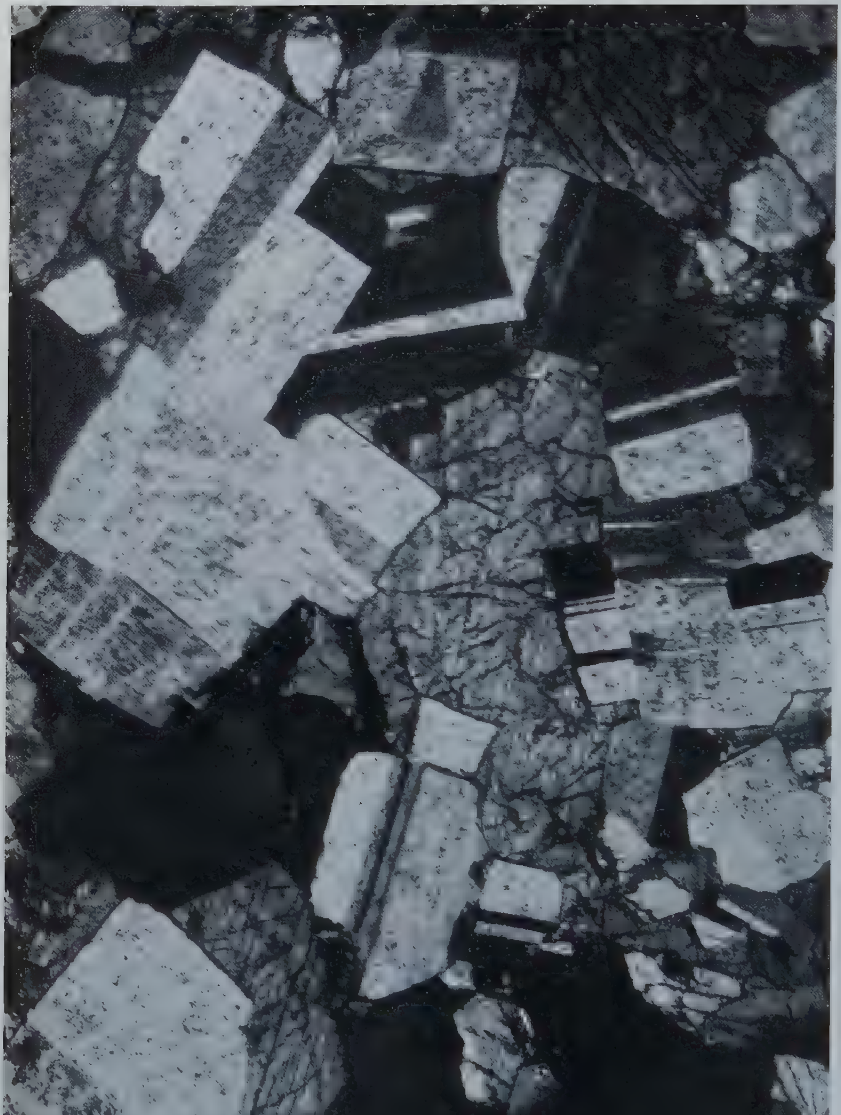
Risbergs granite from the cliffs at Risberget. Left centre: Microcline-twin. Right centre: Plagioclase-twin. Nic. +. Magnif. × 10.



Aplitic Dåasen granite from Losberget. Nic. +. Magnif. × 55.



Gray Rullbo granite at Woxna Älv. Nic. +. Magnif. × 10.



Albitic dyke rock from Rövarberget Hill NE of Woxna. The albite crystals are ophitically arranged within an epidote-base. Nic. +. Magnif. × 22.

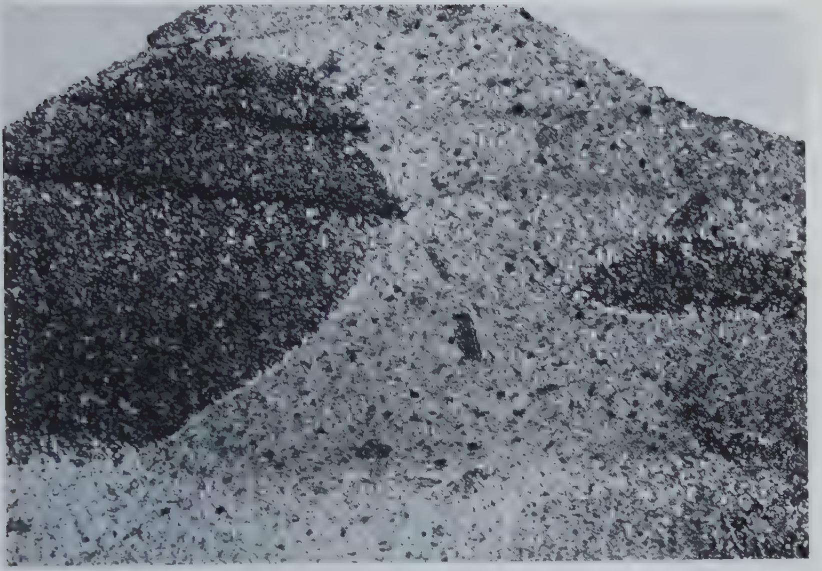


Fig. 1. Secondary schistosity traversing greenstone pebbles of quartzitic Upper Loos conglomerate, N of Woxna Hed. Ord. light, Magnif. × 10.

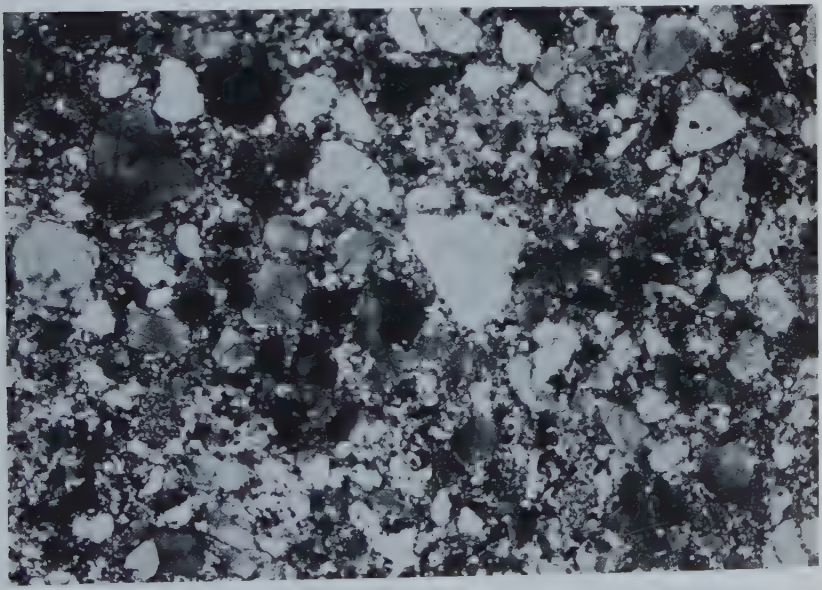
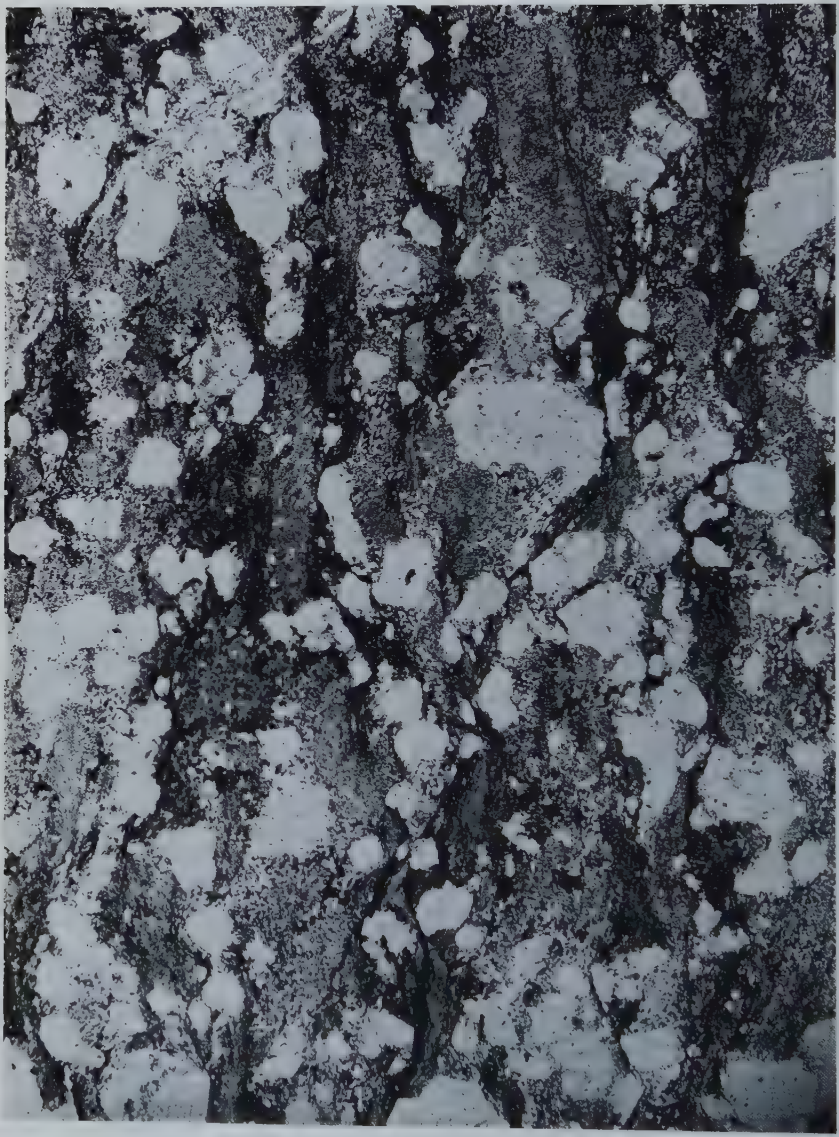


Fig. 2. Upper Loos quartzite at Sandsjöberget. Nic. +. Magnif. × 10.



Arkosic schist east of Noppikoski. Basal strata of the Upper Loos Series.
Big black flaky crystals are biotite, small black spots chlorite.
Ord. light. Magnif. × 10.

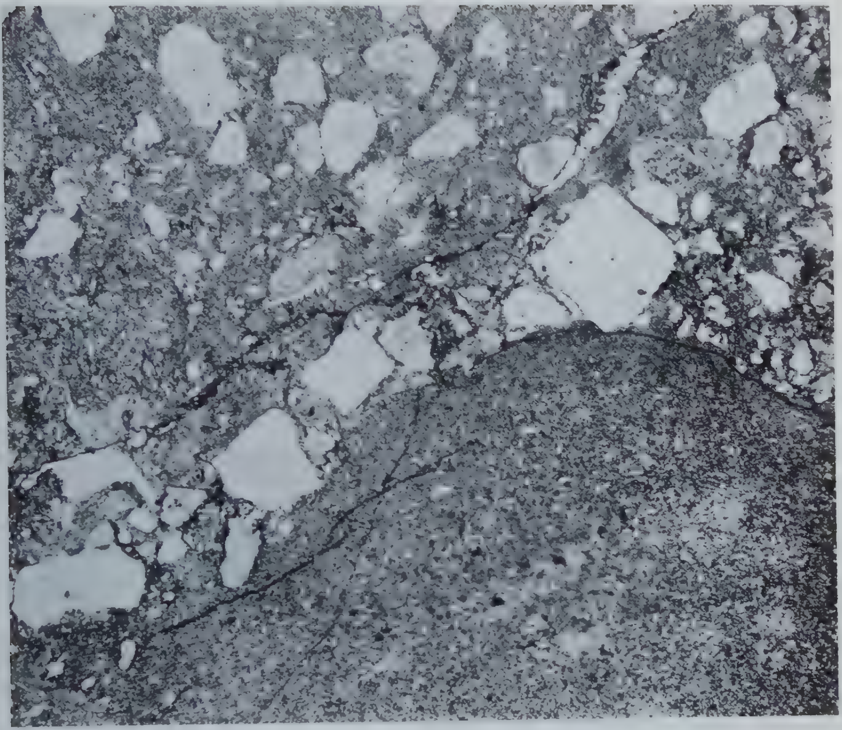


Fig. 1. Contact between arkosic quartzite and Loos-slate at Ore Älv E of Noppikoski. The gray area at the bottom of the picture is slate. Ord. light. Magnif. × 10.

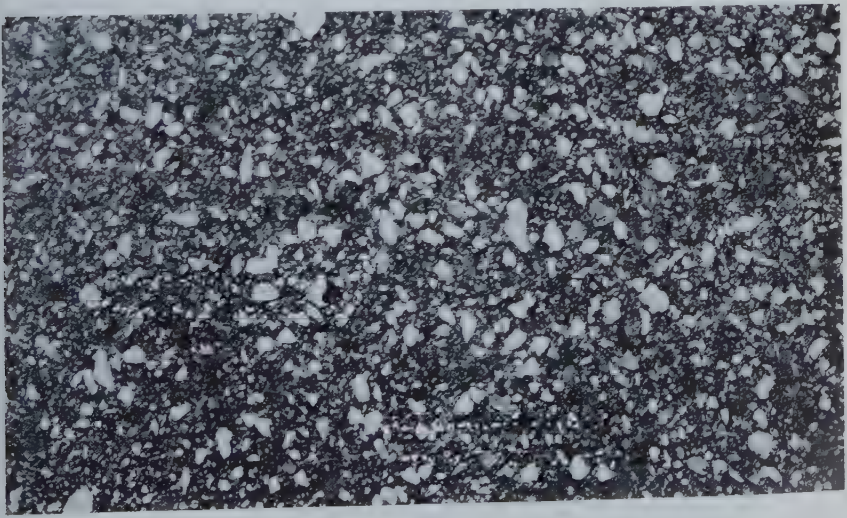
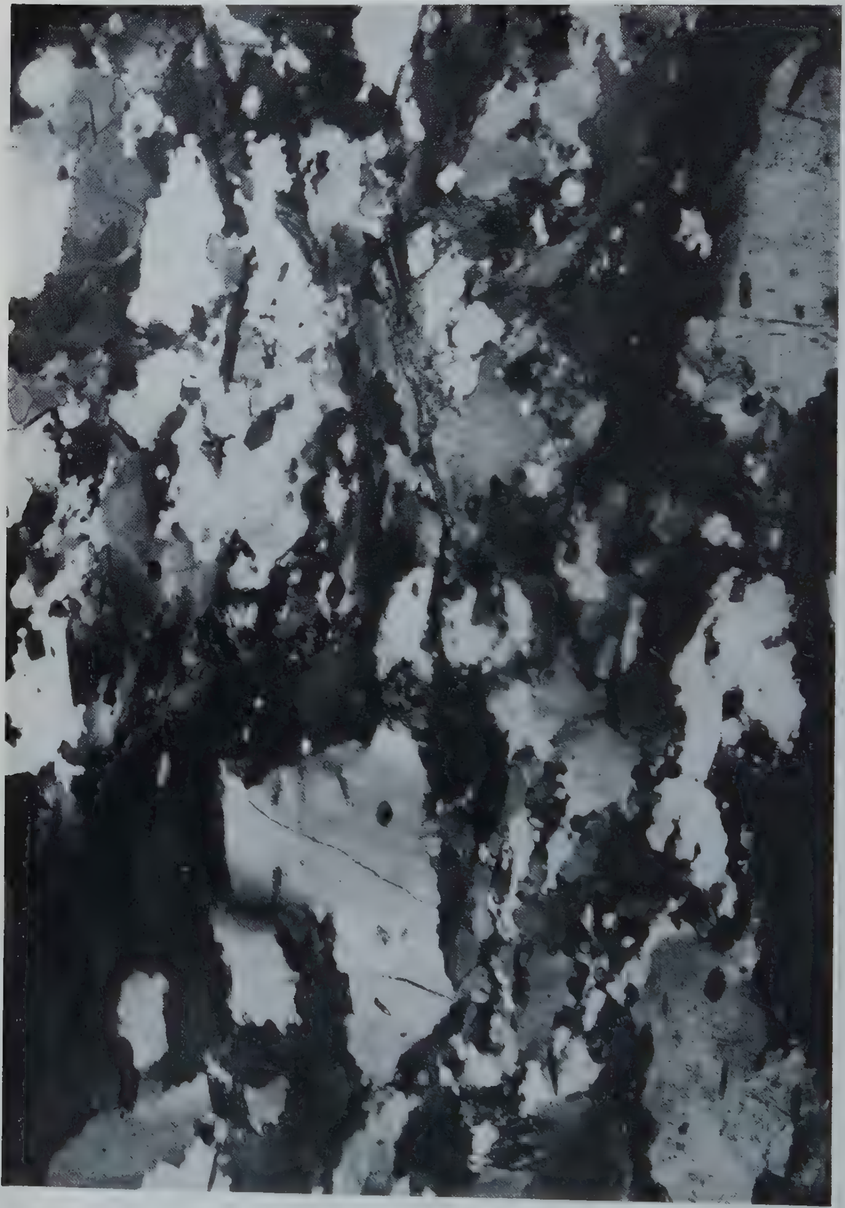


Fig. 2. Graywacke of the Loos Series from N. Hocklan. Ord. light. Magnif. × 10.



Stressed quartzite from Ryggskog; basal part of Upper Loos Series.
Nic. + Magnif. × 35.

The general appearance of the micro-texture of the quartz-porphyries is similar to the above, only that the soda-felspar is sometimes andesinic, the potash-felspar of the ground mass more decidedly microclinic, and the sericitic mica more abundant. Probably, some of the mica is due to an advanced decomposition of the potassic felspar. There is a striking excess of alumina, as shown by the analyses, and expressed by the presence of 2.65 C in the norm. A recalculation of the analysis in terms of the geometrically-measured minerals indicate a phengitic composition of the mica. As set out in more detail later on, the same peculiar excess of alumina is encountered in the quartz-porphyric members of the Noppi- and even the Dala-porphyries too.

In several cases, relics of primary texture are still quite recognizable. The analysed sample of quartz-porphyry, for instance, still shows somewhat diffused, but clearly defined, fluidal movements of the ground mass, and the quartz-porphyry of Hjärpberget even retains some of the original micro-poikilitic texture of the ground mass, the plagioclase phenocrysts at that locality being almost a pure albite, An_{2-3}. Around the quartz phenocrysts, zones rich in quartz occur in the ground mass, which may be taken as the recrystallized needle-quartz-auroles of the younger Noppi-quartz-porphyries to be described later on.

The chemical alteration accompanying the thermal metamorphism produced by the granite, to which reference has already been made, is exemplified by the analyses No. 38 and 39. The latter analysis was executed on a sample taken about 10 yards from the granite contact at Risberget. It clearly indicates an important accession of potassium from the granite (cf. Pl. XXXVII).

Practically all the primary textural features except the quartz-filled vesicles are gone, the sericite having crystallized into fully developed muscovite, and biotite having been added. Earlier titano-magnetite or ilmanite is split up into magnetite and titanite, the latter occasionally retaining cores of ore. The plagioclase, which, probably, was an albite already in the primary rock, has remained so, but all the potassium of the orthoclase has gone to form mica.

The former analysis (No. 38) indicates a somewhat less advanced metamorphism. A considerable part of the potassic felspar still remains as microcline, and the plagioclase retains most of its original lime. While the quartz-porphyry at Risberget has to some extent a hornfelsic appearance — the optic strain of the quartz having been equalized by the recrystallization — the quartz-porphyry of the E. sill retains some of its primary texture. The quartz is still fairly undulous, and the streaks of biotite and muscovite still indicate the primary flow lines within the original magma. Another difference may be noticed

Analysis Nr. 40.

White Quartz-Porphyritic Hälleflinta, western slope of Laxberget (Ls - 438).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	78.55	130.79	Q	53.03	Quartz	60.4	qz	+385
TiO_2	0.12	0.15	Or	30.64	Sericite	33.2	si	613
P_2O_5	0.00	—	Ab	7.32	Albite	5.8	ti	0.70
Al_2O_3	13.04	12.79	C	6.01	Ores and allanite	0.6	al	60.0
Fe_2O_3	0.25	0.16	Σ sal	97.00		100.0	fm	8.0
FeO	0.20	0.28	Hy	1.10			c	0.0
MnO	0.02	0.03	Mt	0.18			alk	32.0
MgO	0.44	1.09	Hm	0.13			mg	0.65
CaO	<0.02	—	Ilm	0.26			k	0.77
Na_2O	0.84	1.36	Σ fem	1.67			c/fm	0.0
K_2O	5.21	5.53	H_2O	1.06				
$H_2O^{+105°}$	1.06	5.88		99.73				
$H_2O^{-105°}$	0.13							
	99.88							

Quantitative System; I: 3: 1: 2 — *Magdeburgose.*
Or: Ab: An — 80.72: 19.20: 0.00.
Sp. gravity $\frac{20°}{4°}$ C = 2.662.

Analysis Nr. 41.

»Hälleflint»-Schist at Svartån Brook (Ls - 692).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	74.47	123.99	Q	44.21	Quartz	46.7	qz	+216.5
TiO_2	0.36	0.45	Or	18.93	Sericite and some biotite	28.9	si	418.5
P_2O_5	0.26	0.18	Ab	21.53	Albite ($Ab_{96}An_4$)	22.4	ti	1.70
Al_2O_3	11.96	11.73	An	0.55	Ores	1.4	al	39.5
Fe_2O_3	2.90	1.82	C	4.08	Apatite	0.6	fm	32.0
FeO	0.58	0.81	Σ sal	89.30		100.0	c	3.0
MnO	0.01	0.01	Hy	5.03			alk	25.5
MgO	2.03	5.03	Ap	0.65			mg	0.53
CaO	0.48	0.86	Mt	0.71			k	0.45
Na_2O	2.57	4.14	Hm	2.41			c/fm	0.10
K_2O	3.21	3.41	Ilm	0.72				
H_2O^+	1.06	5.88	Σ fem	9.52				
			H_2O	1.06				
				99.88				
H_2O^-	0.20							
	100.09							

Quantitative System: I: 3: 1: 3 — *Alaskose.*
Or: Ab: An — 46.16: 52.49: 1.35.
Sp. gravity $\frac{20°}{4°}$ C = 2.719.

Analysis Nr. 42.

»Hälleflint»-tuff south of Rullbo (Ls - 676).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	67.94	113.12	Q	34.48	Quartz	44.3	qz	+134
TiO_2	0.60	0.75	Or	30.01	Muscovite	21.9	si	300
P_2O_5	0.30	0.21	Ab	8.94	Biotite	17.3	ti	2.12
Al_2O_3	14.55	14.27	An	3.33	Plagioclase		al	38.0
Fe_2O_3	1.38	0.86	C	6.12	($Ab_{75}An_{25}$)	12.5	fm	38.0
FeO	3.76	5.23	Σ sal	82.88	Ores	3.3	c	5.0
MnO	0.08	0.11	Hy	11.89	Apatite	0.7	alk	19.0
MgO	2.86	7.09	Mt	2.03		100.0	mg	0.50
CaO	1.06	1.89	Ilm	1.17			k	0.76
Na_2O	1.08	1.74	Ap	0.69			c/fm	0.13
K_2O	5.05	5.36	Σ fem	15.78				
$H_2O^{+105°}$	0.99	5.49	H_2O	0.99				
				99.65				
$H_2O^{-105°}$	0.23	Quantitative System: II: 3: 2: 2 — (No name). Or: Ab: An — 70.98: 21.15: 7.87.						
	99.88	Sp. gravity $\frac{20°}{4°}$ C = 2.767.						

Analysis Nr. 43.

»Hälleflint»-tuff, Nappobäcken Brook, Tandsjö (Ls - 248).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	63.49	105.71	Q	13.03	Quartz	44.9	qz	+ 42
TiO_2	0.44	0.55	Or	60.68	Mica	22.3	si	248
P_2O_5	0.08	0.06	Ab	1.58	Microcline	21.8	ti	1.41
Al_2O_3	15.01	14.72	An	7.48	Albite	1.6	al	34.5
Fe_2O_3	0.89	0.56	C	0.82	Epidote	8.5	fm	32.0
FeO	2.76	3.80	Σ sal	83.59	Titanite	0.7	c	7.0
MnO	0.08	0.11	Hy	12.30	Apatite	0.2	alk	26.5
MgO	3.51	8.71	Mt	1.32		100.0	mg	0.64
CaO	1.66	2.96	Ilm	0.87			k	0.97
Na_2O	0.19	0.31	Ap	0.25			c/fm	0.22
K_2O	10.28	10.91	Σ fem	14.74				
H_2O^+	1.47	8.16	H_2O	1.47				
				99.80				
H_2O^-	0.17	Quantitative System: II: 4: 2: 1 — rang Dacase. Or: Ab: An — 87.01: 2.26: 10.73.						
	100.03	Sp. gravity $\frac{20°}{4°}$ C = 2 675.						

in the reversed ratios between Fe_2O_3 and FeO, the latter porphyry in this respect approaching more closely the less metamorphosed porphyries, N.W. of Loos. Obviously, the metamorphic action of the granite has been considerably stronger at Risberg, which may be explained by the great mass of granite immediately adjoining the porphyry at that locality, as compared with the dyke-like extension of the granite which is supposed to have metamorphosed the sill.

Finally, four analyses of porphyry-tuffs are given, No. 40—43, of which the last one from Tandsjö is extremely potassic. The great number of pegmatite-dykes interfoliating the »hälleflinta» S.E. of Tandsjö, to which reference has already been made (cf. p. 142) is certainly responsible for the unusual accession of potash to these tuffitic schists.

The Risberg Granite.

This brick-red granite derives its name from the Risberg Hill, on the E. shore of the Voxna river, where the granite occurs in its best preserved form. It is extensively exposed, partly in the steep cliffs facing S., partly in the naked rock-slopes towards the river. At a first glance it appears megascopically very little metamorphosed, and is not unlike the acid Rapakivi granite of the Sandsjö type.

A closer investigation, however, soon makes its older age apparent. Large, 1—2 cm long, tabular Karlsbader-twins of microcline give it a somewhat porphyric habit, the other constituents being an opalizing blue quartz, some albitic plagioclase An_7, biotite and, accessorily, magnetite, titanite and apatite. The textural features of the rock show a fairly advanced metamorphism. The bright green biotite is generally extensively chloritized and the central parts of the albite is sericitized, indicating an earlier crystallization rich in potash. The quartz is also optically very unhomogeneous too, the cataclastic features testifying to the participation of the granite in the folding of the Loos-syncline

An analysis of the rock is found appended as No. 44 (cf. Pl. XLI).

The granite clearly intercepts the effusive Loos quartz-porphyry occupying the top of the hill, and strongly metamorphoses it to a considerable depth, as may be studied step by step across the bare rocky slope. It also intrudes, brecciates and alters sub-Loosian schists previously cut by the porphyry. These schists were earlier considered by the author to be of leptitic age, on account of their narrow iron-ore bearing layers. These latter were mined in the 18th century, as iron-ore for the Voxna Blast Furnace. The sediments being intensely folded, underlying leptites may have taken part in the folding and now occupy the position of inlayers, but the iron-ore bearing strata may also be contemporaneous with the ore concentrations of the sparagmitic quartzites and lower sub-Loosian schists of Kuttermäki, to which reference has already been made. Being surrounded by porphyry and gra-

Analysis Nr. 44.

Granite, Cliffs at Risberget Hill (Ls - 419).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	75.51	125.72	Q	41.62	Quartz	39.0	qz	+241	s	82
TiO_2	0.13	0.16	Or	32.77	Microcline	32.1	si	473	A	6.3
P_2O_5	0.14	0.10	Ab	15.72	Plagioclase		ti	0.60	C	0.9
Al_2O_3	11.09	10.88	An	3.04	($Ab_{93}An_7$)	17.4	al	41.0	F	3.6
Fe_2O_3	2.87	1.80	C	0.92	Chlorite (some		fm	21.0	a	17.5
FeO	0.86	1.20	Σ sal	94.07	Biotite)	8.1	c	5.0	c	2.5
MnO	0 01	0.01	Hy	0.81	Magnetite	2.8	alk	33.0	f	10.0
MgO	0.33	0 82	Mt	2.33	Titanite	0.3	mg	0.15	n	3.2
CaO	0.76	1.36	Hm	1.28	Apatite	0.3	k	0.67	k	1.93
Na_2O	1.85	2.98	Ilm	0.25		100.0	c/fm	0.25		
K_2O	5.50	5.85	Ap	0.30						
$H_2O+105°$	0.70	3.38	Σ fem	4.97						
			H_2O	0.70						
				99.74						
H_2O^-	0.15									
	99.90									

Quantitative System I: 3: 1: 2 *Magdeburgose.*
Osann's Type: No. 6. Uthammar (s 80, a 17, c 2, f 11, n 5.4, k 1.65).
Or: Ab: An — 63.59: 30.51: 5.90.
Sp. gravity $\frac{20°}{4°}$ C: 2.604.

nite, their metamorphic story is such a complicated one that, practically, nothing remains of any primary features except the ores which, by the way, are largely altered into garnet-diopside-biotite-skarns. Their mapping as sub-Loosian may, consequently, be regarded as provisional.

The Risberg granite may be traced southwards from Risberget as a red aplitic phase along the Voxna river, the same aplite also cropping out at lower topographic levels at the bottom of the valleys within the gneiss-granite area W. of the Voxna river. (These exposures are too small to be shown on the map.) It gradually changes northwards without any noticeable magmatic joint, into a more basic and, finally, almost white biotite-spotted rock of slight gneissose habit.

Svedmark and Blomberg already noticed this gray rock, and mapped it as a separate type. Its connection with the true Risberg type is still somewhat obscure. In common with the red granite, it intersects the sub-Loosian schists, for instance N. of Voxnahed, at the same time becoming contaminated and developing garnets along the contact. At Stormyråsen Hill, N. of Voxnahed, it still keeps its red colour and general habit within the central portion of the massive, surrounding itself by a marginal gray zone. The change in colour is due to an in-

Analysis Nr. 45.

Mica-Granite at Woxna Älv (Ls - s - 168).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	72.39	120.53	Q . . . 34.00	Muscovite 20.2 } 25.4	qz +168	s 78.8
TiO_2	0.15	0.19	Or . . 31.21	Biotite 5.2	si 404	A 8.2
P_2O_5	0.54	0.38	Ab . . 23.59	Plagioclase	ti 0.67	C 1.3
Al_2O_3	14.91	14.63	An . . 1.94	($Ab_{93}An_7$) . 25.6	al 49	F 1.9
Fe_2O_3	0.40	0.25	C . . . 3.87	Quartz 38.8	fm 10	a 21.5
FeO	1.04	1.45	Σ sal . 94.61	Microcline . . 9.0	c 7	c 3.5
MnO	0.01	0.01	Hy . . 2.24	Apatite and some	alk 34	f 5.0
MgO	0.38	0.94	Mt . . 0.62	Tourmaline 1.2	mg 0.31	n 4.4
CaO	1.12	2.00	Ilm . . 0.35	100.0	k 0.55	k 1.46
Na_2N	2.80	4.52	Ap . . 1.27		c/fm 0.69	
K_2O	5.30	5.63	Σ fem . 4.48			
H_2O+	0.72	4.00	H_2O . . 0.72			
			99.81			
	99.76	Quantitative System: I: 4: 1: 3 — *Liparose.* Osann's Type: No. 11. Big Timber Creek (s 80.5, a 20.0, c 3.5. f 6.5, n 1.9, k 1.68).				
H_2O^-	0.24	Or: Ab: An — 55.01: 41.57: 3.42.				
	100.00	Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.630.				

creasing amount of plagioclase and white mica, the plagioclase grading into an An_{20} composition. N.E. of Storlugnet Power Station, about a mile N. of Voxnahed, however, the granite locally grows remarkably rich in both biotite and muscovite ($2V_{550} = 32°$) while the anorthite content of the plagioclase remains at 7 %. This miceous rock is quite homogeneous and has undoubtedly been rather rich in volatiles, as is evidenced by the comparatively high percentage of apatite as well as by the presence of tourmaline. Analysis No. 45 gives the composition of this very striking variety of the Risberg granite (cf. Pl. XLIII).

At the Power Station, the granite assumes a gneissose structure, but, microscopically, is less dynamically metamorphosed than the typical rock of Risberget itself. The plagioclase within certain dioritic parts of the granite runs as basic as An_{37}, at the same time becoming increasingly zonal. This zoning is mostly alternating with a basic kernel, an acid shell and, finally, with a basic margin. The green biotite of the typical Risberg granite remains, however. Megascopically, this rock looks more like a fairly homogeneous and well-preserved Mansjö-granite than a younger rock.

When intruding the sub-Loosian schists, N. of Voxnahed, its metamorphic influence differs, however, from that of the Mansjö granite when migmatitizing the leptite schists. It does not brecciate, assimilate and migmatitize, as does the Mansjö-granite, but occurs as lit-par-lit injections along the bedding plains of the sediments, surrounding itself with an intense aurole of newly formed, colourless mica. There is a striking enrichment of potash in the surrounding rocks, as well as within the granite itself. This also holds good when it intercepts the old gneiss granites and migmatites.

Along the Voxna river, it is found intruding the sub-Loosian schists as well as the basic tuffites, but it is not observed cutting the upper Loosian sediments. At Rullbo it becomes »homogeneous gneissose», the schistosity running about parallel to the contact of the Rätan granite.

At the same time, the colour of the rock becomes a pure white. As shown by analysis No. 46, the basidity of the plagioclase increases to An_{43}, developing, simultaneously, a most bewildering alteration of the zoning, the following crystal having been taken as a common example:

Kernel -An_{43} -An_{30} -An_{42} -An_{30} -An_{40} -An_{30} — Shell.

The zones are almost homogeneous and very sharply defined, and each may be determined on the universal stage with a high degree of accuracy (cf. Pl. XL, Fig. 2). The slight schistosity of the rock marked by the arrangement of the biotite may, partly at least, be protoclastic even if cataclastic features are never absent. This may be deduced from the quartz, which is partly homogeneous and partly very undulous, a feature hardly in correspondence with a purely cataclastic metamorphism. The partial crystallization of the quartz may also be due to thermal influence of the adjoining Rätan granite, the marginal phase of the latter at Saltsjöbäcken being almost undistinguishable from the white Risberg granite. The refusion and contamination which has occurred along the contact, giving rise to hybrid rocks, will be further discussed in the following chapter on the Rätan granite (cf. p. 262). N.E. of Hamra Church, a granodioritic somewhat gneissose, fairly wide dyke cuts across the strike of the old migmatitic gneiss granite. Its genetic connection with the white granite is shown by analysis No. 47. It is unusually rich in microcline and biotite which latter seems to be mostly an autometamorphic alteration-product of a green hornblende, some pistazite ($(\gamma - \alpha)_{550} = 0.049$; $2V_{550} = 68°$) too having been formed during the alteration.

Of quite a different character to the Rullbo granite — which may be looked upon as the basic differential pole of the Risberg granite — is the Dåasen granite, E. of Loos. On Blomberg's map (cf. 1) this granite was marked as Rätan granite while, at the beginning of this survey, the present writer was inclined to refer it to the Mansjö granite. Further

Analysis Nr. 46.

White Gneissose Granite at Woxna river. North West of Rullbo (Ls - 183).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	70.68	117.68	Q . . . 28.41	Plagioclase	qz +131	s 77
TiO_2	0.20	0.25	Or . . 12.38	($Ab_{57}An_{43}$) . . 66.0	si 337	A 6.1
P_2O_5	0.17	0.12	Ab . . 37.22	Quartz . . . 16.2	ti 0.71	C 4.2
Al_2O_3	16.04	15.73	An . . 16.41	Microcline . . 10.7	al 45.0	F 2.3
Fe_2O_3	0.81	0.51	C . . . 0.51	Biotite (with	fm 10.5	a 14.5
FeO	0.87	1.21	Σ sal . 94.93	some musco-	c 18.0	c 10.6
MnO	0.02	0.03	Hy . . 2.55	vite) . . . 4.9	alk 26.5	f 5.5
MgO	0.58	1.44	Mt . . 1.17	Magnetite . . 1.2	mg 0.38	n 7.7
CaO	3.50	6.24	Ilm . . 0.42	Titanite . . . 0.6	k 0.24	k 1.53
Na_2O	4.39	7.08	Ap . . 0.34	Apatite . . . 0.4	c/fm 1.68	
K_2O	2.11	2.24	Σ fem . 4 48	100.0		
$H_2N + ^{105°}$	0.39	2.16	H_2O . . 0.39			
			99.80			
		Quantitative System: I: 4: 3: 4 — *Yellowstonose.* Osann's Type: No. 26. Bold Mt (s 76.5, a 14.0, c 9.0, f. 7.0, n 6.9, k 1.57).				
$H_2O - ^{105°}$	0.21	Or: Ab: An — 18.75: 56.39: 24.86.				
	99.97	Sp. gravity $^{20°}_{4°}$ C: 2.646.				

Analysis Nr. 47.

Granodiorite at main road East of Hemsjö Lake and Hamra Church (Ls - 153).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	63.72	106.09	Q . . . 18.92	Plagioclase	qz +59	s 71.5
TiO_2	0.55	0.69	Or . . 17.20	($Ab_{61}An_{39}$) . 40.9	si 229	A 5.7
P_2O_5	0.34	0.24	Ab . . 25.70	Quartz . . . 22.1	ti 1.51	C 5.1
Al_2O_3	15.79	15.49	An . . 20.87	Microcline . . 13.8	al 33.5	F 7.5
Fe_2O_3	1.14	0.71	Σ sal . 82.69	Hornblende and	fm 31.0	a 9.5
FeO	3.91	5.44	Hy . . 12.95	Pistazite . . 10.6	c 18.0	c 8.5
MnO	0.06	0.08	Mt . . 1.65	Biotite . . . 8.9	alk 17.5	f 12.0
MgO	3.02	7.49	Ilm . . 1.06	Magnetite . . 1.6	mg 0.52	n 6.3
CaO	4.59	8.18	Ap . . 0.73	Titanite . . . 1.4	k 0 39	k 1.37
Na_2O	3.05	4.92	Σ fem . 16.39	Apatite . . . 0.7	c/fm 0.57	
K_2O	2.87	3.05	H_2O . . 0.72	100.0		
$H_2O + ^{105°}$	0.72	3.00	99.80			
		Quantitative System: II: 4: 3: 3: — *Harzose.* Osann's Type: No. 25. Vaskö (s 71, a 9.0, c 7.5, f 13.5, n 6.5, k 1.37).				
$H_2O - ^{105°}$	0.25	Or: Ab: An — 26.97: 40.30: 32.73.				
	100.01	Sp. gravity $^{20°}_{4°}$ C. 2.762.				

Analysis Nr. 48.

Dåasen Granite from Dåasenberget Hill. East of Loos Church (Ls - 369).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	70.79	117.87	Q . . . 25.17	Plagioclase	qz +123	s 78
TiO_2	0.33	0.41	Or . . 33.98	($Ab_{83}An_{17}$) . 30.8	si 355	A 7.3
P_2O_5	0.05	0.04	Ab . . 25.17	Microcline . . 30.7	ti 1.21	C 1.7
Al_2O_3	13.82	13.56	An . . 7.20	Quartz . . . 27.8	al 41.0	F 3.9
Fe_2O_3	0.28	0.18	C . . . 0.10	Biotite and some	fm 18.0	a 17.0
FeO	3.22	4.48	Σ sal . 91.62	muscovite . 9.7	c 8.0	c 4.0
MnO	0.06	0.09	Hy . . 6.50	Titanite . . . 0.4	alk 33.0	f 9.0
MgO	0.40	0.99	Mt . . 0.42	Ores 0.4	mg 0.17	n 4.4
CaO	1.43	2.55	Ilm . . 0.62	Apatite . . . 0.2	k 0.56	k 1.53
Na_2O	2.97	4.79	Σ fem . 7.54	100.0	c/fm 0.44	
K_2O	5.78	6.14	H_2O . . 0.56			
$H_2O+110°$	0.56	3.11				
			99.72			
$H_2O-110°$	0.37					
	100.06					

Quantitative System: I: 4: 2: 3 — *Toscanose.*
Osann's Type: N:o 12. Alby (s 79, a 17.5, c 3.5, f 9, n 4.4, k 1.62).
Or: Ab: An — 51.21: 38.24: 10.55.
Sp. gravity $\frac{20°}{4°}$ C: 2.650.

studies have convinced him of its being more closely related to the Risberg type than to any other granite present within the field.

It is a somewhat gneissose, fairly coarse, pink, potassic granite, not unlike the Risberg marginal phase at Storlugnet, but more porphyric. The phenocrysts are large, irregularly tabular, microcline and oligoclase-crystals (An_{17}) within a coarse base of microcline, plagioclase and colourless quartz. Biotite marks the schistosity, titanite ores and apatite being accessories. The analysis is given as No. 48.

The texture is a cross-breed between the Mansjö and the Risberg granite, the microcline being sometimes fairly dotted by myrmikite. The oligoclase crystals, too, are sometimes pronounced poikilitically intergrown by quartz. Within the E. marginal parts of the massive, where the distance to the Rätan granite is small, the oligoclase is filled by oriented lathes of unaxial muscovite, constituting a separation of the original potash molecules of the felspar (cf. Pl. XL, Fig. 1). In the ground mass, too, muscovite occurs together with the biotite, the optical characteristics, however, being somewhat different ($2V_{550} = 35°$). The granophyric texture also seems to increase towards the younger granite.

This suggests a rather strong thermal metamorphism at the time of the intrusion of the Rätan granite. The gneissose structure, on the other hand, seems to have arisen at different periods. Firstly, a N.S. schistosity is observable, especially along the E. boundary towards Lake Dåasen, but also on the W. and S. sides of the Dåasen Hill. This schistosity may be due both to a primary protoclastic structure parallel to the intrusion contact towards the sub-Loosian schists as well as to a secondary cataclastic structure imposed at the time of the synclinal folding of the Loos-basin.

Secondly, a gneissose banding, at right angles to the first one, is evident within the northern part of the massive. This structure is certainly totally dynamic and has been developed by the cross-folding of the syncline at the emplacement of the Rätan granite. The comparatively old habit of the Dåasen granite, may, consequently, be explained by exposure to shearing stresses during three consecutive epochs.

Outside the zone of convergent dynamic metamorphism, the granite is better preserved. Its southern extension at Losberget and Karlsberg registers only one gneissose structure, parallel to the folding axis of the syncline. Within these marginal parts of the granite, the characteristic concentration of mica and, especially, muscovite — emphazised when describing the Voxnahed granite — is also repeated. At Losberget, analysis No. 50, the mica of the red granite is still mostly biotite, but the plagioclase has dropped to An_{8-14}, attaining the same albitic composition as that of the typical Risberg granite. Within the aplitic marginal rock at Karlsberg, however, the muscovite rules supreme, as indicated by the mode of analysis No. 49 (cf. Pl. XLII). As previously intimated, these true aplites are sometimes very difficult to distinguish from the aplitic gneisses of sedimentary origin, especially as the aplitic granites, certainly to a large extent, are contaminated by absorbed quartzitic sediments. Even analysis is of small use when attempting to establish their magmatic or sedimentary origin, as illustrated by analysis No. 51 compared with analysis No. 49. The former sample is taken from a banded rock cut by the magmatic aplites and unmistakably a strongly metamorphic sediment of intimate field-connection with the sparagmitic quartzites. Attention has already been drawn to the intense accession of potash recognizable within the younger and older sub-Loosian sediments, this feature being a true characteristic of the contact metamorphism originated by the Dåasen granite.

The connection between this latter granite and the Risberg granite, W. of the Loos-syncline, is happily not limited to the correspondence in pneumatolitic potash-metamorphism alone. Their stratigraphic emplacement, agrees, too, as far as the sub-Loosian schist is concerned. The aplitic dykes of the Dåasen granite may be observed cutting through the whole pack of sub-Loosian schists, S. of the Losberg Cot-

Analysis Nr. 49.

Light-reddish Aplitic Granite, Norra Karlsberg (Ls - 982).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	74.32	123.74	Q . . . 32.20	Microcline . . 39.8	qz +183	s 80.7
TiO_2	tr.	—	Or . . 39.47	Plagioclase	si 445	A 8.6
P_2O_5	0.06	0.04	Ab . . 22.06	(Ab_{90} An_{10}) . 25.1	ti 0.00	C 0.7
Al_2O_3	14.57	14.29	An . . 2.75	Quartz . . . 29.9	al 51.5	F 0.7
Fe_2O_3	0.48	0.30	C . . . 2.04	Muscovite . . 5.2	fm 4.5	a 26.0
FeO	0.35	0.49	Σ sal . 98.52	100.0	c . 3.5	c 2.0
MnO	0.01	0.01	Hy . . 0.36		alk 40.5	f 2.0
MgO	0.04	0.10	Mt . . 0.69		mg 0.08	n 3.7
CaO	0.53	0.95			k 0.63	k 1.50
Na_2O	2.63	4.24	Σ fem . 1.05		c/fm 0.83	
K_2O	6.64	7.05	H_2O . 0.33			
$H_2O^{+105°}$	0.33	1.83	99.90			
$H_2O^{-105°}$	0.11					
	100.07					

Quantitative System: I: 4: 1: 2 — *Omeose.*
Osann's Type: No corresponding type.
Or: Ab: An — 61.40: 34.32: 4.28.
Sp. gravity $^{20°}_{4°}$ C: 2.612.

Analysis Nr. 50.

Red Gneiss-Granite, Losberget Hill (Ls - v - 168).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	77.79	129.52	Q . . . 40.36	Quartz . . . 39.5	qz +262	s 83.3
TiO_2	0.05	0.06	Or . . 26.14	Plagioclase	si 522	A 7.1
P_2O_5	0.00	—	Ab . . 27.26	(Ab_{92} An_8) . 30.2	ti 0.24	C 0.6
Al_2O_3	12.11	11.88	An . . 2.77	Orthoclase . . 25.3	al 48.0	F 1.3
Fe_2O_3	0.45	0.28	C . . . 1.02	Mica, mostly	fm 8.0	a 23.5
FeO	0.78	1.09	Σ sal . 97.55	biotite . . 4.9	c 4.0	c 2.0
MnO	0.01	0.01	Hy . . 1.11	Titanite . . . 0.1	alk 40.0	f 4.5
MgO	0.09	0.22	Mt . . 0.68	100.0	mg 0.11	n 5.3
CaO	0.55	0.98	Ilm . . 0.12		k 0.48	k 1.85
Na_2O	3.22	5.19	Σ fem . 1.91		c/fm 0.53	
K_2O	4.41	4.68	H_2O . 0.41			
$H_2O^{+105°}$	0.41	2.28				
			99.87			
$H_2O^{-105°}$	0.12					
	99 99					

Quantitative System: I: 3: 1: 3 — *Varingose.*
Osann's Type: No. 4. Milford (s 82.5, a 24.0. c 2.0, f 4.0 n 5.4, k 1.74).
Or: Ab: An — 46.89: 48.54: 4.57.
Sp. gravity $^{20°}_{4°}$ C: 2 624.

Analysis Nr. 51.

Aplitic Gneiss, Losberget Hill (Ls - 175).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	77.23	128.59	Q	40.84	Quartz	37.8	qz	+245	s	82
TiO_2	0.15	0.19	Or	25.63	Albite	26.0	si	487	A	7.1
P_3O_5	0.07	0.05	Ab	25.66	Microcline	20.5	ti	0.76	C	0.5
Al_2O_3	12.16	11.93	An	0.55	Biotite	9.2	al	45.0	F	3.0
Fe_2O_3	0.67	0.42	C	2.24	Muscovite	5.0	fm	17.5	a	20.0
FeO	1.48	2.06	Σ sal	94.92	Magnetite	1.0	c	2.0	c	1.5
MnO	0.07	0.10	Hy	3.70	Titanite	0.3	alk	35.5	f	8.5
MgO	0.63	1.56	Mb	0.95	Apatite	0.2	mg	0.35	n	5.2
CaO	0.30	0.53	Ilm	0.29		100.0	k	0.48	k	1.76
Na_2O	3.01	4.85	Ap	0.24			c/fm	0.11		
K_2O	4.36	4.63	Σ fem	5.18						
$H_2O + 105°$	0.30	1.66	H_2O	0.30						
				100.30						
$H_2O - 105°$	0.05									
	100.48									

Quantitative System: I: 3: 1: 3 — *Alaskose.*
Osann's Type: No. 5. Elk Peak. (s 81, a 20·5, c 2.0, f 7.5,
n 5.0, k 1.69).

Or: Ab: An — 49.44: 49.50: 1.06.

Sp. gravity $\frac{20°}{4°}$ C: 2.662.

tage. Another dyke, intruding the quartzites W. of Karlsberg (cf Section II—II), even shows an unmistakable affinity with the norma Risberg granite, both as regards general habit and textural composition It displays at the same time undoubted quartz-porphyric features even if these, to some extent, have been obliterated by the stron stresses acompanying the adjoining faulting. The typical blue opalizin quartz, common both to the Loos porphyries and the Risberg granit also occurs in this dyke, which may, originally, represent a feedin dyke of the quartz-porphyry flows or a sill of hypabyssic magm intermediary between the porphyry and the granite. Other typica sills of red Risberg granite are found N. of Kuttermäki.

There is one objection, however, to our definitely acknowledging th Dåasen granite as contemporaneous with the Risberg granite, and tha is the difficulty in explaining the contact between the former granit and the greenstone on the E. slope of Tallsjöberget. This contact i exposed some 5—10 m. below the crest of the hill, but even detaile microscopic studies have failed to decide which is the younger rock In the field, the granite seems to intersect the greenstone and the greenstone appears to intersect the granite. Undoubtedly a very stron activation of the wall rock has taken place at the time of the intrusion

Analysis Nr. 52.

Pegmatitic Dyke (granitic), Rövarberg Hill (Wx-253).

Analyst: H. v. Eckermann.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	65.94	109.79	Q . . . 18.69	Albite 30.6	qz +74	s 73.5
TiO_2	0.29	0.36	Or . . 25.07	Microcline . . 25.3	si 278	A 6.9
P_2O_5	0.10	0.07	Ab . . 30.39	Quartz . . . 19.9	ti 1.01	C 4.2
Al_2O_3	16.90	16.58	An . . 17.52	Epidote . . . 19.3	al 42.0	F 4.5
Fe_2O_3	0.50	0.31	Σ sal . 91.67	Topaze . . . 4.2	fm 11.0	a 13.5
FeO	2.01	2.80	Di . . 3.34	Titanite . . . 0.5	o 21.0	c 8.0
MnO	0.00	—	Hy . . 1.85	Apatite . . . 0.2	alk 26.0	f 8.5
MgO	0.32	0.79	Mt . . 0.71	100.0	mg 0.19	n 5.7
CaO	4.68	8.35	Ilm . . 0.58		k 0.44	k 1.35
Na_2O	3.58	5.78	Ap . . 0.27		c/fm 1.95	
K_2O	4.26	4.52	Fr . . 0.37			
$H_2O^{+105°}$	0.94	5.22	Σ fem . 7.12			
Cr_2O_3	0.00	—	H_2O . 0.94			
S	tr.	—				
F	0.15	0.79	99.73			
	99.67	Quantitative System: I: 4: 3: 3 — *Amiatose.* Osann's Type: No. 24. Doberschütz (s 73, a 11, c 7.5, f 11.5, n 6.3, k 1.43).				
$H_2O^{-105°}$	0.22	Or: Ab: An — 34.35: 41.64: 24.01.				
	99.89	Sp. gravity $\frac{20°}{4°}$ C: 2.710.				

ut exposures at right angles to the contact are too small to allow a udy of the gradual changes within both the rocks. The majority of ne evidence is in favour of the granite being the younger, but it certainly strange that no dykes of granite are found elsewhere within ne greenstones. The contact between the effusive greenstones, S. of borrtjärn and N.W. of Karlsberg, is also somewhat dubious, notwithanding the epidotization of the calcite filling of the greenstone vesicles, ndicating an exogeneous thermal metamorphism.

The possibility of the Dåasen granite being somewhat older than ne true Risberg granite must, consequently, not be disregarded but orne in mind. The consequence of the possibility would be a chronogical position of the Dåasen granite somewhere between the Mansjö nd the Risberg types, the granite being rather an aftermath of the rmer than a forerunner of the latter. The granitization of the sparagitic quartzite, underbedding the sub-Loosian schists, would then, aybe, be referrable to this Dåasen granite.

Finally, a peculiar dyke rock, cutting across the general strike of ne migmatite area at Rövareberget Hill N.E. of Voxna, may be menoned in this connection. No evidence is available of its relation to ne Risberg granite, but its dynamically unaffected texture refers it in any case to a younger age than that of the Mansjö granite. There is really nothing to prevent its being of Rätan age, or even a remote differentiate of the Loos-greenstone-magma. The analysis of the rock is given as No. 52. The dyke is greenish-white, and of aplitic rather than pegmatitic character. The microscopic picture is a striking one (cf. Pl. XLIV), extremely nice tabular albite twins lying in a base o epidote, cryptomicrocline and quartz. The dyke bears every sign o having been rich in volatiles, an unusual percentage of topaze accompanying the accessories titanite and apatite.

Disregarding this last vagabonding dyke, which actually fits in nowhere, the writer tried to plot the analysis of this group of granites

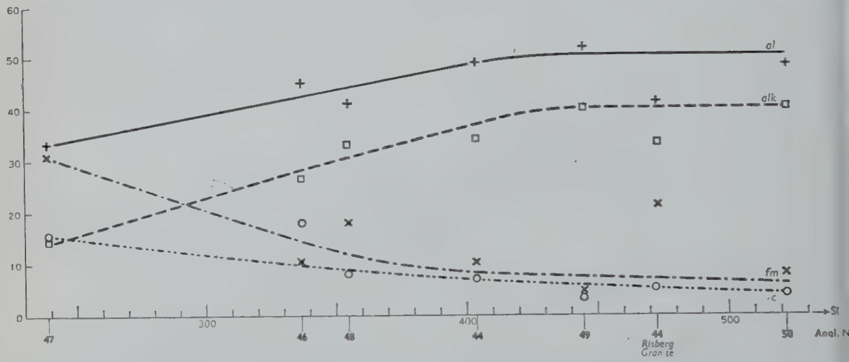


Fig. 11. NIGGLI diagram of the Risberg granite group.

into a NIGGLI variation diagram, but the result has not been very encouraging (cf. Fig. 11). Any combination of the plotted points into consecutive, reasonable curve representing a differentiation sequenc seems to be out of question.

The typical Risberg granite stands out alone with an unusually hig »fem»- and depressed »al»- and »alk»-values. The granites at Rullbo Dåasen and Losberget may be combined to plot a curve representin a fairly good average, but even that curve is hardly a true record o the real differentiation sequence. All told, the suspicion entertaine as to the relationship of the Risberg and Dåasen granites is considerabl strengthened by this chemical computation, and the author must adm that he has no reasonable explanation to offer. The extent to whic these rocks have been contaminated by leptitic and sub-Loosian sed ments must probably be made the subject of special study before definite position can be assigned to each of them in the chronologic succession. At present, the term Risberg granite may be taken as d noting a group of granites limited in age upwards by the upper Loos sedimental epoch, and downwards by the diastrophism period of migmatitization.

The Upper Loos Sedimental Series.

A resedimentation of the pyroclastic rocks deposited during the eruptions of the greenstone and porphyries, must have occurred even while the volcanic activity still lasted. The banded acid and basic tuffs seem to be reassorted, even if an alternatingly basic and acid eruption is not quite excluded. Such banded tuffs being covered by later lava flows, clearly shows this reassortment to have taken place before the end of the volcanism.

The post-volcanic erosion seems to have developed gradually, as typically tuffitic sediments are found grading into real slates. Even the colour of the slates is intimately connected with the eroded rock-ground. The slates south of Ryggskog, for instance, bordering on the greenstones, are greenish, while the slates west and north of Ryggskog are of a pure gray colour. It is suggested that the present emplacement of the slates, notwithstanding their strong folding, is not very far removed from their original sedimentation-basins. No basal conglomerates of any extent have been found even if some arkoses are conspicuously pebbly in a small way. The unconformity between the Loos-eruptives and their sediments is best shown by the sandstone-quartzite cap at Ryggskog overlying the quartz-porphyries. The locality is easily found, a watch-tower to prevent forest fires having been built on the outcrop.

The base of this sandstone is decidedly pebbly and contains opalizing blue-quartz grains which are easily traceable to the amygdales of the effusive quartz-prophyry. Its joint towards the porphyry is not exposed but very nearly so, and the striking topography hardly allows of any other interpretation than an overbedding. The strike and dip of the quartzite is quite different to that of the porphyry, which latter takes part in the left limb of the big Loos-syncline, while the tectonic disturbance of the quartzite seems to be connected with the later faulting of the Loosian sediments. Microscopically, the quartzite shows sign of strong dynamic stress, even if the primary clastic features are very well preserved. Close to the base the dynamic crushing of the rock is stronger, indicating a certain amount of horizontal thrust movement along the base (cf. Pl. XLVIII).

Actually, not a single perfectly undisturbed contact between the lower Loos-eruptives and the upper Loos-sediments is exposed any-

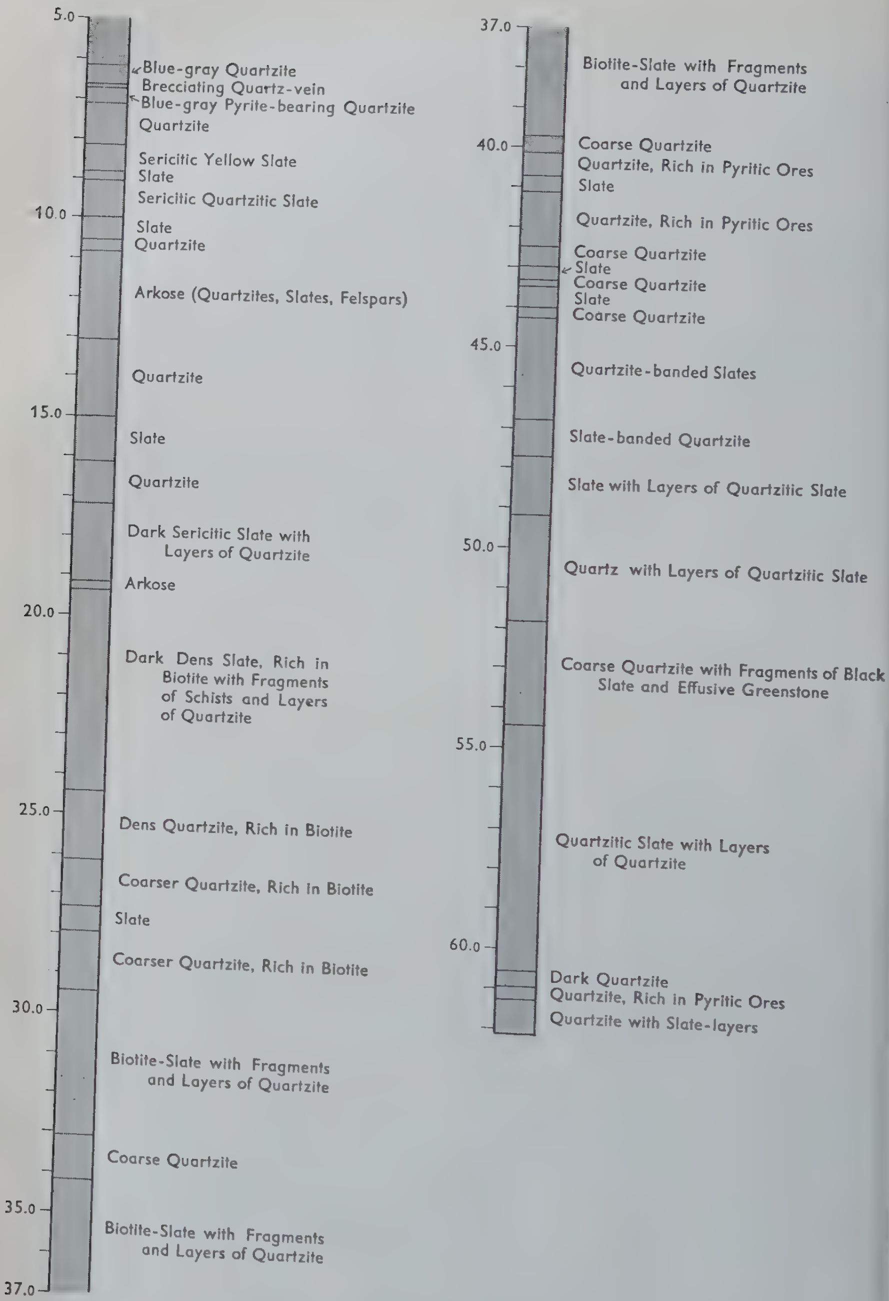

5.0
Blue-gray Quartzite
Brecciating Quartz-vein
Blue-gray Pyrite-bearing Quartzite
Quartzite
Sericitic Yellow Slate
Slate
Sericitic Quartzitic Slate
10.0
Slate
Quartzite
Arkose (Quartzites, Slates, Felspars)
Quartzite
15.0
Slate
Quartzite
Dark Sericitic Slate with Layers of Quartzite
Arkose
20.0
Dark Dens Slate, Rich in Biotite with Fragments of Schists and Layers of Quartzite
25.0
Dens Quartzite, Rich in Biotite
Coarser Quartzite, Rich in Biotite
Slate
Coarser Quartzite, Rich in Biotite
30.0
Biotite-Slate with Fragments and Layers of Quartzite
Coarse Quartzite
35.0
Biotite-Slate with Fragments and Layers of Quartzite
37.0
37.0
Biotite-Slate with Fragments and Layers of Quartzite
40.0
Coarse Quartzite
Quartzite, Rich in Pyritic Ores
Slate
Quartzite, Rich in Pyritic Ores
Coarse Quartzite
Slate
Coarse Quartzite
Slate
Coarse Quartzite
45.0
Quartzite-banded Slates
Slate-banded Quartzite
Slate with Layers of Quartzitic Slate
50.0
Quartz with Layers of Quartzitic Slate
Coarse Quartzite with Fragments of Black Slate and Effusive Greenstone
55.0
Quartzitic Slate with Layers of Quartzite
60.0
Dark Quartzite
Quartzite, Rich in Pyritic Ores
Quartzite with Slate-layers

Fig. 12. Sectional diagram of drill-hole No. 19 through Upper Loos sediments. Figures indicate depth in metres.

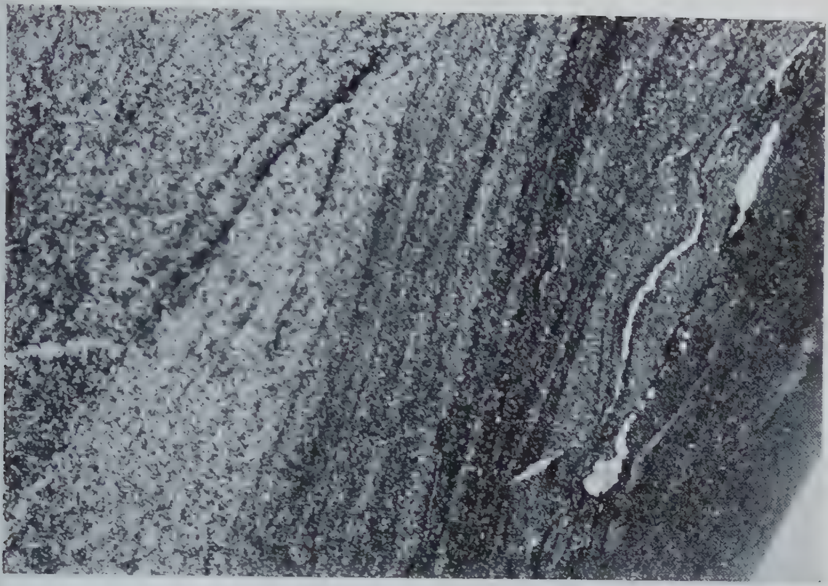


Fig. 1. Tuffitic sediments at Kolarsjöbäcken, W. Hocklan. Current bedding. Ord. light. Magnif. × 10.

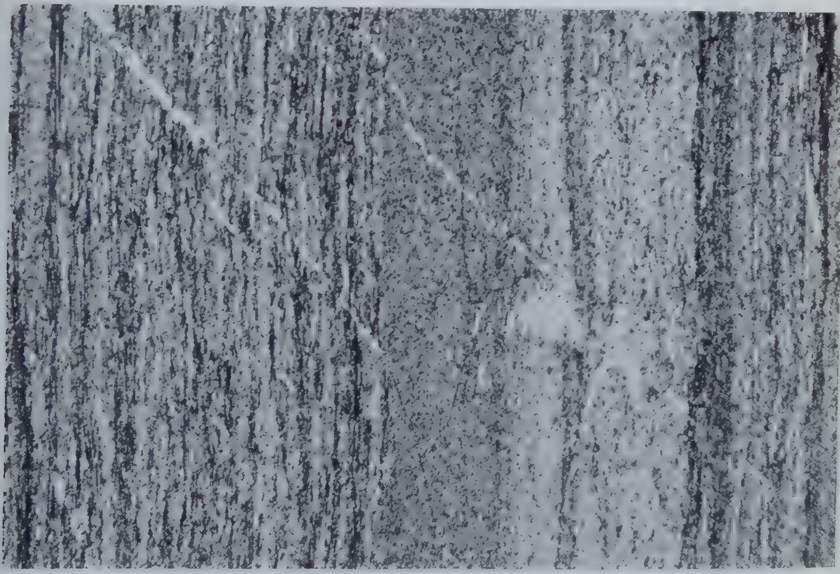


Fig. 2. Banded slates of the Upper Loos Series SW of Romberg, north of Loos. Ord. light. Magnif. × 10.

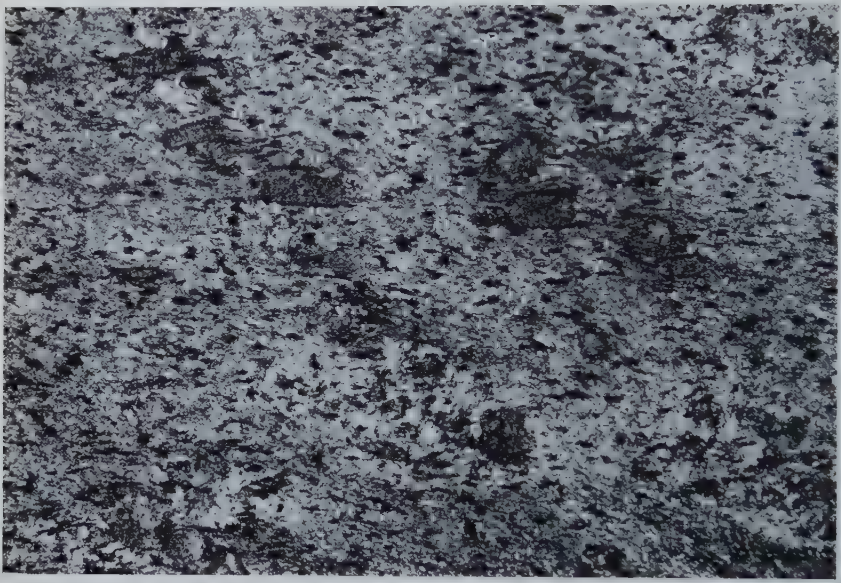


Fig. 1. Basic tuffitic schists at W. Hocklan. Porphyroblastic dark green chloritoid. Ord. light. Magnif. × 10.

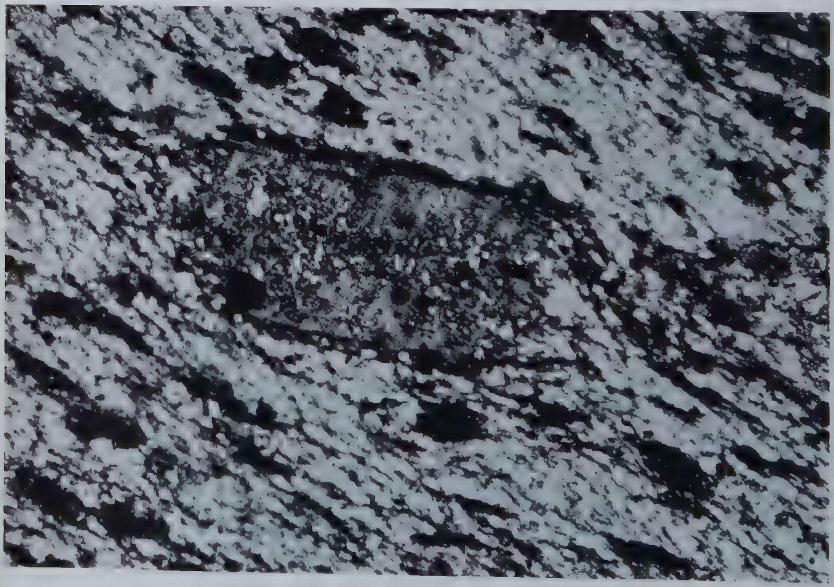


Fig. 2. Enlarged magnification of chloritoid porphyroblast of Fig. 1, showing poeciloblastic structure. Ord. light. Magnif. × 55.

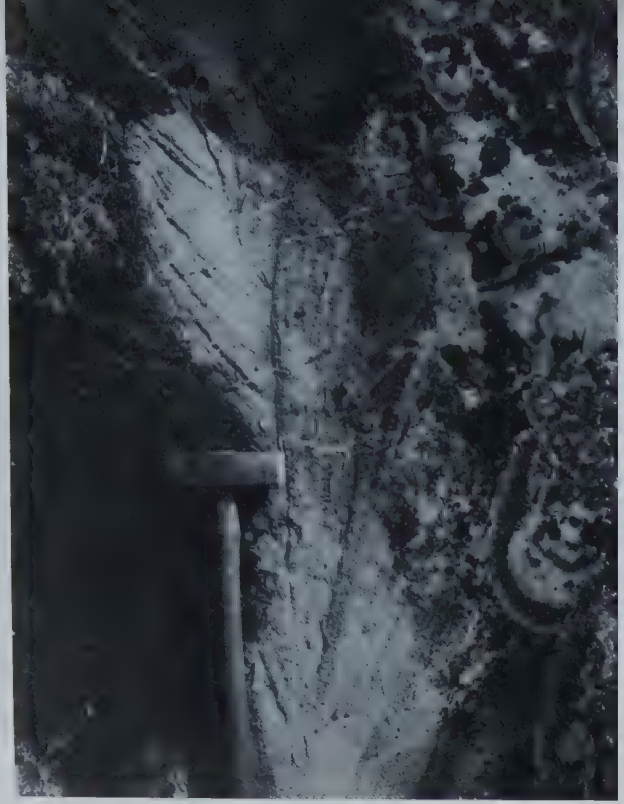


Fig. 1. Current bedding in Loos-quartzites, east of Noppikoski. The left bedding-planes are truncated. The quartzite is »younging» towards the right side of the picture.

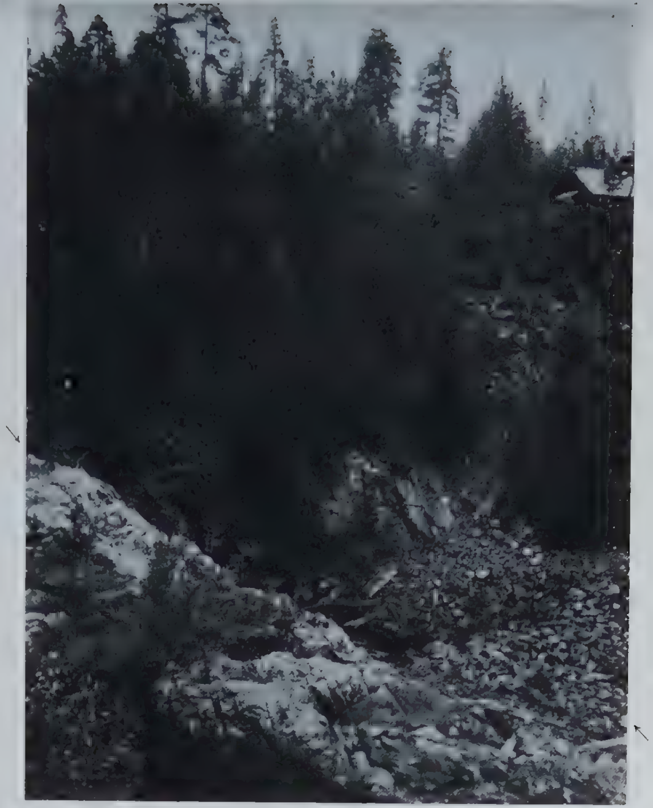


Fig. 2. The unconformity (arrows) between the Noppi-quartz-porphyry (in the foreground) and the underlying quartzites (in the background). The view is taken from Noppikoski Bridge, looking NE.

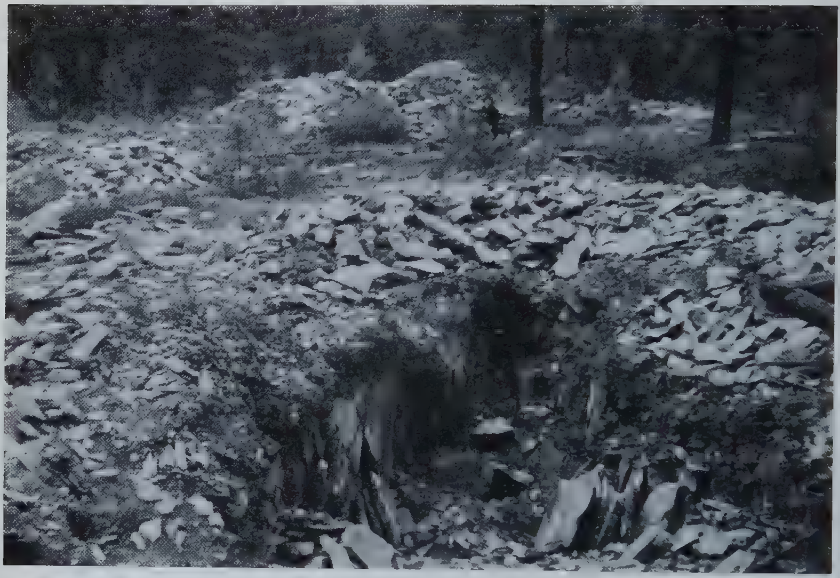


Fig. 1. Slate quarries at Ryggskog.

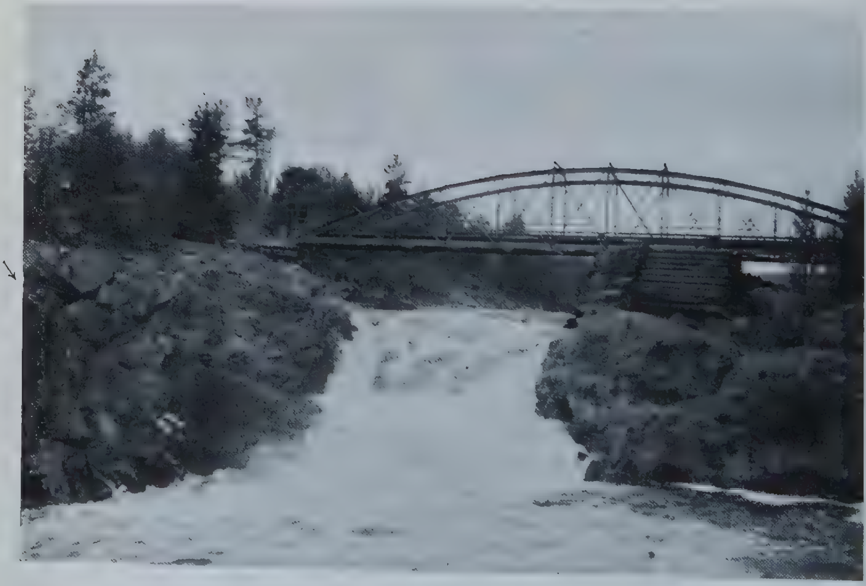
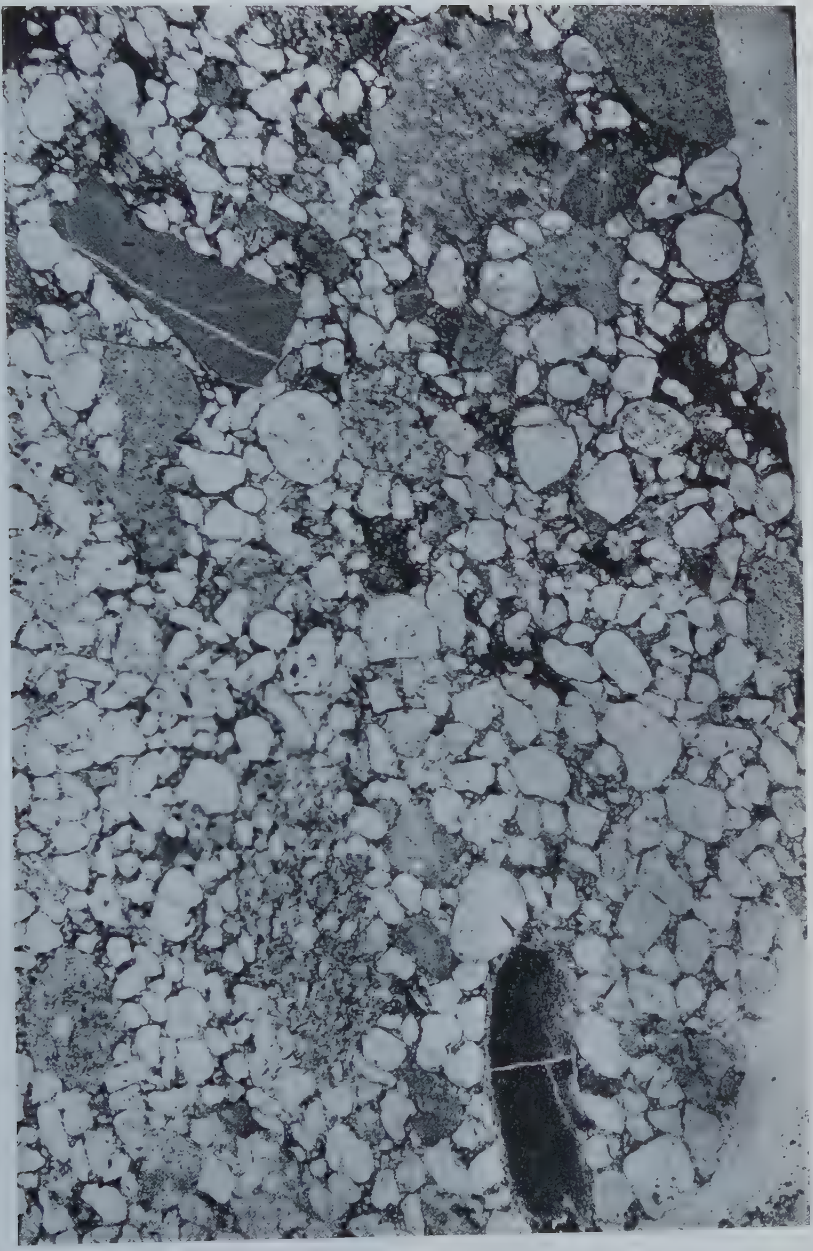
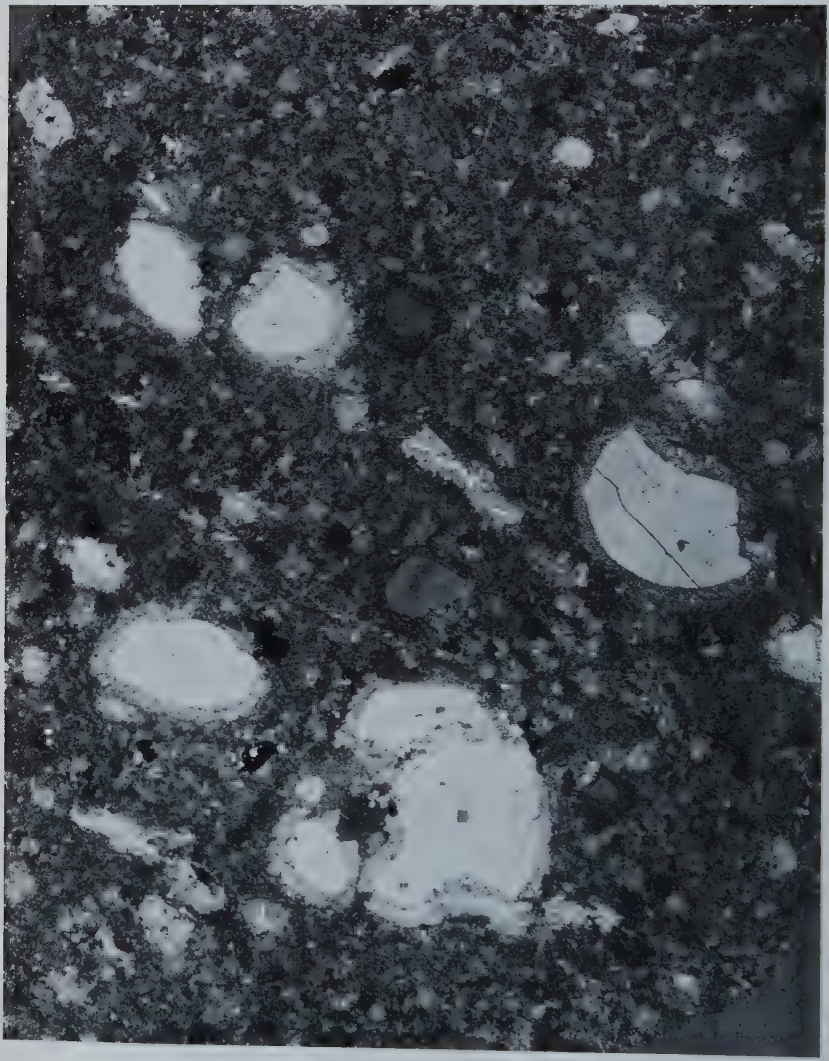


Fig. 2. Road bridge at Noppikoski. The arrow indicates the contact between the Sub-Noppi conglomerate to the left and the Noppi quartz-porphyry to the right.



Sub-Noppi conglomeratic sandstone at Noppikoski. To the upper left, fragment of slate. Ord. light. Magnif. × 10.



Noppi quartz-porphyry at Ormtjärnknoppen. Marginal zones of acicular quartz surround the quartz-phenocrysts, lying in a »spotty» micro-poikilitic base. Nic. +. Magnif. × 20.

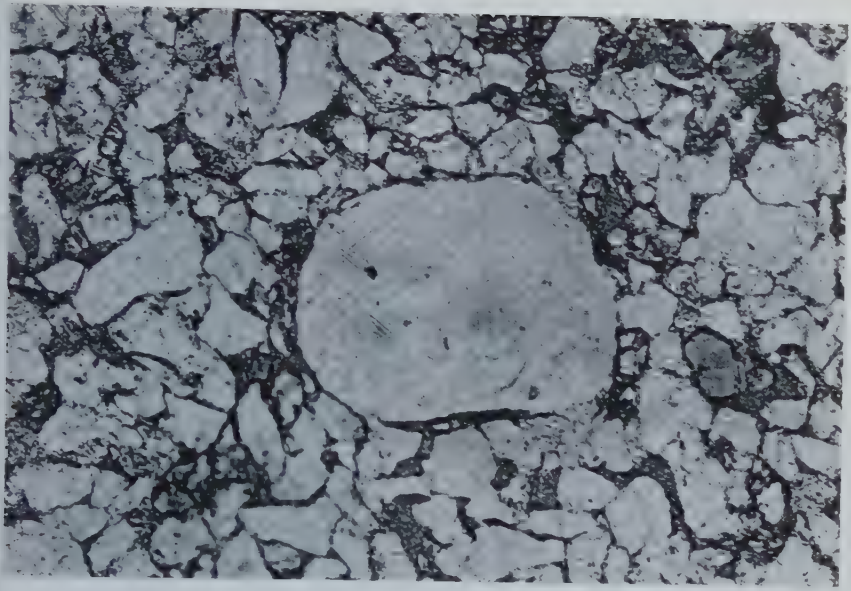


Fig. 1. Quartzitic sandstone of the Noppi series from Tallsjöbäcken. Ord. light. Magnif. × 55.

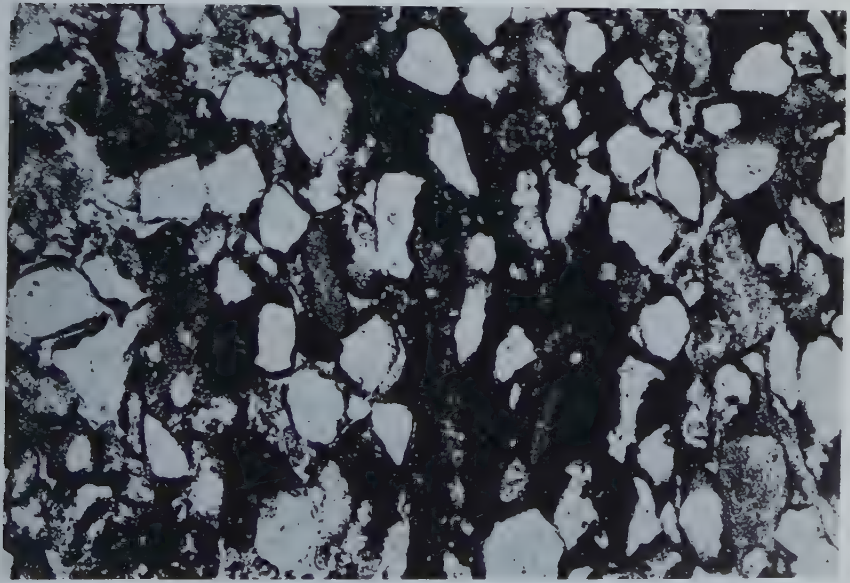


Fig. 2. Graywacke of the Noppi series from Lekattkölen. Ord. light. Magnif. × 55.

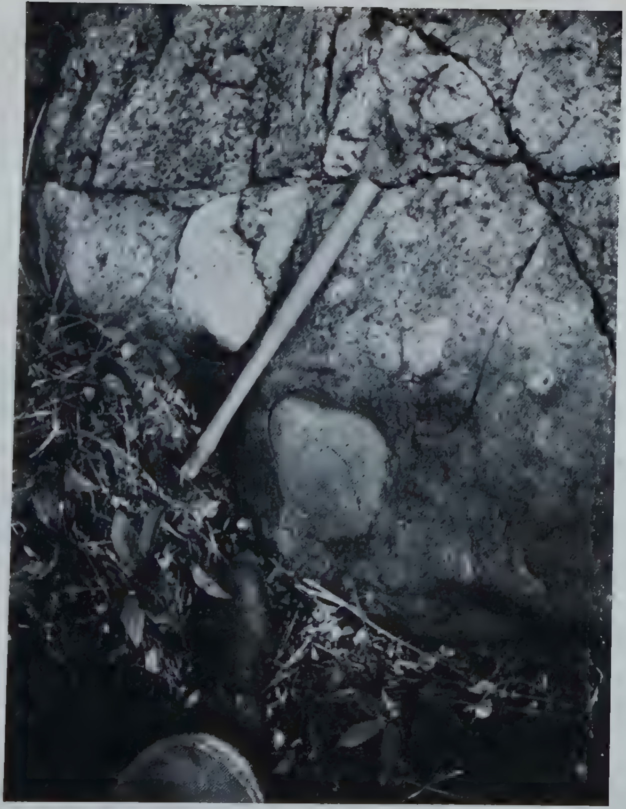


Fig. 1. The Sub-Jotnian conglomerate at Tallsjöbäcken.

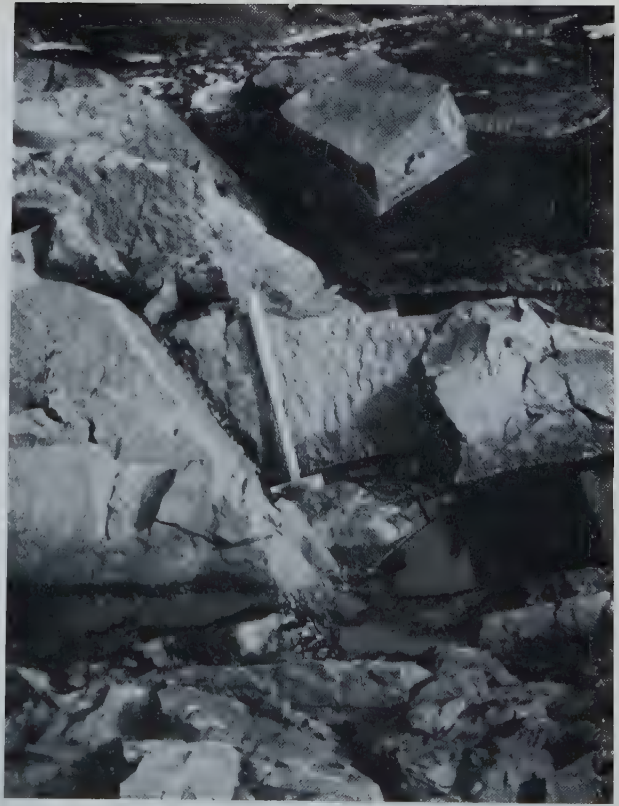


Fig. 2. Ripple-marks in quartzite-banded Noppi-slates at Tallsjöbäcken.

where within the Loos-region proper. The unconformity may, nevertheless, be clearly demonstrated in a circumstantial way. Resting on the Ryggskog quartzite are the slates, occupying the big swampy area to the S.W. and N.W. These slates are exposed at the big quarries close to the watch-tower, where their tectonic position may be determined. To the S.E. of the Ryggskog hillock, the drill-holes of the Boliden Co. have passed through slates, pebbly grits and quartzites, lying in a position undoubtedly indicating a stratigraphic level above the porphyries and greenstones. This is further emphasized by fragments of effusive greenstones repeatedly found within the bottom portions of the drill holes (cf. Fig. 12). As previously shown, there is no indication of a hiatus between the greenstone and the porphyry, both belonging to one and the same eruptive epoch. Consequently, the inference may be drawn that the quartz porphyry and the superimposed slates must be separated by a considerable unconformity.

Greenstone pebbles, embedded in quartzose sediments between Voxna Hed and Ryggskog, constitute further evidence, the pebbles having participated in the succeeding strong folding of the area (cf. Pl. XLV, Fig. 1), as shown by the secondary planes of schistosity running right through the pebbles.

Outside the Loos-area proper, this unconformity is represented at the base of the Loos-series, E. of Noppikoski, by arkoses, which, however, rest on old gneiss-granites and not, as the writer previously supposed when publishing the preliminary report on the district, on Risberg granite. The small area S.E. of Tandsjö, where Loos-schists have been down-faulted, has also proved to be of evidential value. The Loos quartz-porphyries are there covered by tuffitic sediments, which in turn are clearly overlaid by quartzites, in every respect similar to those of Ryggskog. The unconformity may, consequently, be considered as firmly established, and the following succession to be the normal one:

Youngest: Pebbly yellow-brown quartzites (basal conglomerate of the Noppi-series).
Violet-gray quartzites.
Slates.
Graywackes.
White, gray or green quartzites.
Oldest: Arkose.

These series are differently developed at different localities within the area. While, within the Loos-area proper, the slates predominate, the quartzites constitute the bulk of the sediments between Tandsjö and Noppikoski. Only at the latter place is a complete series preserved in unbroken sequence, even if it is — so to say — condensed, no important phase of the sedimentation being unrecorded, but no great thicknesses being attained either.

An enlarged map of the Noppikoski area is found in the appended Fig. 13. The bottom arkose was already observed by SVEDMARK, who called it a sparagmite. He did not observe its grading from perfectly fresh granite of Group I, or maybe Group II, through gradually increasing weathering for a distance of 10—30 m. into a quartzose arkose where most of the felspar is gone and replaced by mica and chlorite. Still retaining its pebbly character, this quartzite grades, N. of the Ore river, into a dark green vitreous quartzite which gradually becomes evenly grained and denser. The green colour, in analogy with the green slates, is derived from basic material between the quartz grains, probably originating from the weathering of adjacent but now removed greenstones. Its present mineral phase is one of ferrous diopside and green chlorite, the latter arranged tangentially around the quartz grains. Some sillimanite needles and albite are also included in the interstices between the grains. The chemical composition is given by analysis 53 (cf. Pl. XLVI).

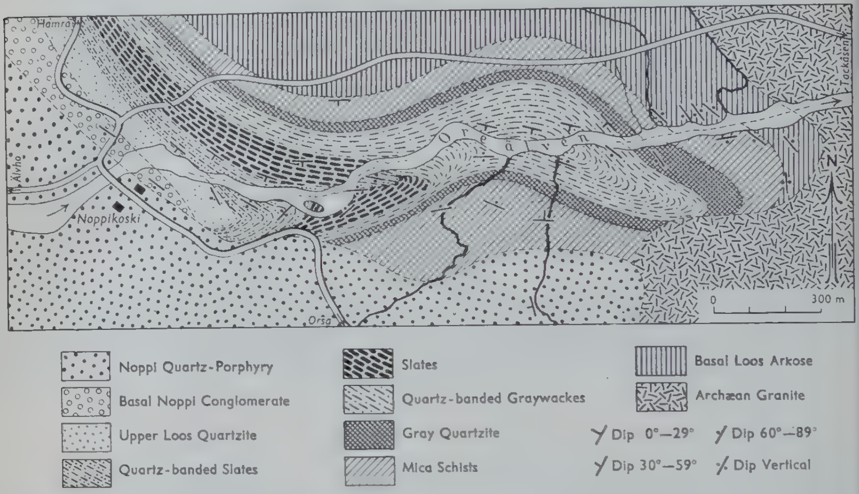


Fig. 13. Sketch Map of the Noppikoski district.

When ascending the sequence, the arkose gradually changes into graywackes interfoliated by fine-grained phyllitic layers rich in biotite and sericite (cf. Pl. XLVII). Analysis 54, taken from the big slate

Analysis Nr. 53.

Green Quartzitic Arkose (Ls - s - 112) from Ore Älven.

Analyst: R. Blix.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values
SiO_2	82.43	137.25	Quartz	66.9	si = 468
TiO_2	0.09	0.14	Diopside	21.2	qz = +360
P_2O_5	0.08	0.06	Chlorite	6.3	al = 11.5
Al_2O_3	3.26	3.20	Sillimanite	4.1	fm = 52.5
Fe_2O_3	1.82	1.14	Albite	1.1	c = 35.5
FeO	1.39	1.94	Titanite	0.2	alh = 0.5
MnO	0.14	0.20	Apatite	0.2	mg = 0.71
MgO	4.24	10.52		100.0	k = 0.00
CaO	5.60	9.99			c/fm = 0.67
Na_2O	0.14	0.23			
K_2O	—	—			
$H_2O+^{105^\circ}$	0.58	3.22			
$H_2O-^{105^\circ}$	0.04	—			
	99.81	Sp. gravity $^{20^\circ}_{4^\circ}$C: 2.801.			

Analysis Nr. 54.

Quartzitic Slate (Ls - s - 100) at Stensjö Brook south of Övre Gässmyrtjärn.

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values
SiO_2	70.55	117.47	Quartz	40.6	si = 359
TiO_2	0.54	0.85	Mica	23.4	ti = 2.60
P_2O_5	0.10	0.07	Plagioclase		al = 34.5
Al_2O_3	11.48	11.26	($Ab_{96}An_4$)	18.0	fm = 24.5
Fe_2O_3	1.79	1.12	Sillimanite	8.3	c = 23.0
FeO	0.73	1.02	Andalusite		alh = 18.0
MnO	0.04	0.06	Calcite	6.1	mg = 0.59
MgO	1.90	4.71	Magnetite	2 3	k = 0.47
CaO	4.24	7.56	Titanite	1.0	c/fm = 0.95
Na_2O	1.95	3.15	Apatite	0.3	qz = +187
K_2O	2.50	2.65		100.0	
$H_2O+^{105^\circ}$	1.64	9 10			
$H_2O-^{105^\circ}$	0.15	—			
CO_2	2.68	6.09			
	100.29	Sp. gravity $^{20^\circ}_{4^\circ}$C: 2.764.			

basin, W. of Loos, represents such a transitory form between quartzitic graywackes and slates. Another sample, analysis 55, collected to the S.W. of the former, is of a more slaty type. The first of the two is typically clastic and very rich in sericitic mica as well as in fragments of sillimanite, andalusite and tourmaline crystals. It is

Analysis Nr. 55.

Black Biotite-bearing Slate. Stensjöbäcken Brook north of Stormyren, Loos (Ls - 574).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values	
SiO_2	64.33	107.19	Quartz	34.8	si	248
TiO_2	0.72	0.90	Plagioclase	24.8	qz	+ 86
P_2O_5	0.20	0.14	(varying from		ti	2.08
Al_2O_3	14.76	14.48	oligoclase to		al	34.5
Fe_2O_3	1.44	0.90	andesine)		fm	36.5
FeO	3.92	5.46	Microcline	13.8	c	13.5
MnO	0.10	0.14	Biotite and Chlorite	20.1	alk	15 5
MgO	3.98	5.94	Epidote	3.3	mg	0.62
CaO	3.33	9.87	Apatite and ores	3.2	k	0.69
Na_2O	1.32	2.13		100.0	c/fm	0.37
K_2O	4.44	4.71				
$H_2O+^{105°}$	0.20	1.11				
$H_2O-^{105°}$	0.25	—				
	100.05	Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.770.				

Analysis Nr. 56.

Slate from Ryggskog Quarries (Ls - 564).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values	
SiO_2	70.60	117.55	Mica, mostly		si	= 448
TiO_2	0.56	0.70	biotitic	55.9	qz	= + 254
P_2O_5	tr.		Quartz	31.8	ti	= 2.65
Al_2O_3	15.22	14.93	Microcline	6.9	al	= 56.5
Fe_2O_3	3.67	2.30	Albite	2 6	fm	= 18.0
FeO	0.58	0.81	Ores	2.8	c	= 2.0
MnO	0.04	0.06		100.0	alk	= 23.5
MgO	1.11	2.75			mg	= 0.58
CaO	0.28	0.50			k	= 0.92
Na_2O	0.30	0.48			c/fm	= 0.12
K_2O	5.38	5.71				
$H_2O+^{105°}$	2.04	11.32				
$H_2O-^{105°}$	0.27	—				
	100.05	Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.772.				

partly cemented by calcite. The second is richer in minute brown biotite-flakes, which add to its dark colour as does also the powdery ores distributed throughout the texture. On account of the larger percentage of micas, the clastic fragments are more separated from each other. Beautiful current bedding structures are observable, not

Analysis Nr. 57.
Yellow Slate from Ryggskog Quarries (Ls - 789 a).
Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %		Niggli's ref. values
SiO_2	59.41	98.92	Sericitic Mica	65.1	si = 257
TiO_2	0.62	0.97	Quartz	25.2	qz = + 99
P_2O_5	0.36	0.25	Ores	7.5	ti = 2.70
Al_2O_3	20.62	20.23	Albite	1.6	al = 52.5
Fe_2O_3	4.24	2.68	Apatite	0.6	fm = 31.5
FeO	3.07	4.27		100.0	c = 1.5
MnO	0.03	0.04			alk = 14.5
MgO	2.64	6.55			mg = 0.54
CaO	0.30	0.54			k = 0.95
Na_2O	0.19	0.31			c/fm = 0.04
K_2O	5.00	5.31			
$H_2O + 105°$	3.26	18.10			
$H_2O - 105°$	0.30	—			
	100.04	Sp. gravity $^{20°}_{4°}$C: 2.740.			

only in the field but also microscopically. Undoubtedly the first rock derives its material from the metamorphosed tuffitic and sub-Loosian schists while the latter may represent detritus, mostly from granites (cf. Pl. LI, Fig. 1).

The grading into extremely fine-grained and argillicious slates is illustrated by the analyses No. 56—57, executed on samples from the Ryggskog quarries. Of the two, the latter represents the most psammitic type found to the E. of the workable slates and quite unsuitable for the production of whetstones. A comparison of the analyses shows the disappearing of the biotite and the increase of the sericite up to $^2/_3$ of the rock. At the same time the potassic felspar declines, and only some albite remains (cf. Pl. LII, Fig. 1).

These soft yellow slates not occurring at Noppikoski but being encountered in the drill-holes, S.E. of Ryggskog (cf. Fig. 12), are of very young appearance, and several of my colleagues, when visiting the field, have spent hours looking in vain for fossils. I may admit having taken a lively part in their labours, until the drill-holes definitely proved their connection with ordinary slates.

These latter are gray, strongly pressed and schistose at an oblique angle of 25°—30° to the original bedding. The stratification is beautifully preserved, strongly reminding one of the varved structure of glacial clays. Peculiar oval nodular protrusions are noticed on the planes of sedimentation, — not on those of transversal schistosity. They vary in size from 4 to 10 cm. in length and look like concretions. Cross-sections, when examined under the microscope, fail, however, to show any concentrations of authigenic constituents. They are simply small areas, where the continuous sedimentation has been discontinued. In a way, their margins are even unconformable to the bedding (cf. Fig. 14). A minute quantity of grayish-brown powder is attached to their always convex surface, but all attempts to identify this powder have so far failed.

Two suggestions offer themselves. The first is that the protrusions may represent some kind of jelly-fish. This does not, however, seem reasonable, on account of the age of the slates, even if one must not forget the still older »Corycium enigmaticum» of the Finnish-Bothnian phyllites, interpreted by SEDERHOLM as possibly being algae or fossils (32). The second suggestion is that of gas-bubbles, developed in the slime, breaking the continuity of the sedimentation and finally compressed by the weight of the continued sedimentation. At the flattening out of the bubbles an unconformity between the gas-film and the bedding especially along the circumference might be expected.

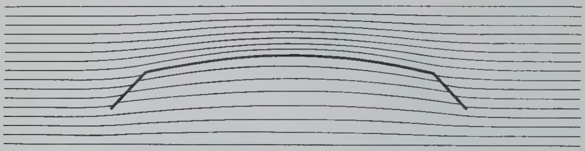


Fig. 14.

The slates are overlain somewhat abruptly by the upper quartzites, even if there sometimes occur transitionary beds of alternatingly quartzose and slaty banding, such as is the case at Noppikoski. The upper quartzites are of distinct violet gray hue and, in consequence of their tectonic position along the big fault-lines, generally strongly brecciated by milk-quartz veins (cf. Pl. XLV, Fig. 2).

These quartzites attain their greatest thickness in a precipitous ridge, W. of Lake Sandsjön, and analysis No. 58 shows their almost pure quartzose composition, only a small quantity of sericitic mica being present. A study of the quartz grains right through the sedimental succession indicates a diminishing dynamic stress towards the top-strata, expressed by decreasing recrystallization and optic strain. Reference has already been made to the breccia at the top, due to the faulting, and to the tuffitic matrix of the breccia. Near the top, layers of more psammitic sedimentation, rich in hematite, are met with, and the corresponding phenomenon is repeated N. of Noppikoski at Häst-

Analysis Nr. 58.

Quartzite. Eastern slope of Sandsjöberget Hill (Ls - 541).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %
SiO_2	95.13	158.39	Quartz . . 89.9
TiO_2	0.06	0.09	Sericitic
P_2O_5	0.05	0.03	Mica . . 9.3
Al_2O_3	2.20	2.16	Ores . . . 0.5
Fe_2O_3	0.39	0.24	Apatite . 0.3
FeO	0.08	0.11	100.0
MnO	tr.	—	
MgO	0.23	0.57	
CaO	0.26	0.46	
Na_2O	tr.	—	
K_2O	0.99	1.05	
H_2O^{+105}	0.50	2.77	
H_2O^{-105}	0.12		
	100.01	Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.660.	

Analysis Nr. 58 a.

Violet Quartzitic Sandstone. Hästmyren north of Noppikoski (Ls - 559).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Actual mineral composition %
SiO_2	83.43	138.91	Quartz . . 74.8
TiO_2	0.45	0.56	Sericitic
P_2O_5	0.10	0.07	Mica . . 21.7
Al_2O_3	7.64	7.49	Limonite
Fe_2O_3	2.02	1.26	(partly
FeO	0.14	0.19	pseudo-
MnO	tr.	—	morphs of
MgO	0.37	0.92	Goethite) 2.6
CaO	0.19	0.34	Rutile and
Na_2O	tr.	—	Ilmenite 0.6
K_2O	2.63	2.79	Apatite . 0.3
H_2O^{+105}	1.43	7.94	100.0
H_2O^{-105}	0.12		
	100.52	Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.682.	

myren, where a quartzite is strikingly violet, due to the presence of limonite as pseudomorphs after small goethite crystals (cf. analysis Nr. 58 a).

As already intimated, the position of the Råberg-quartzite is somewhat doubtful, and the absence of sufficient outcrops has prevented a definite answer to the question being obtained. Tectonically, one is given the impression that the Loos upper quartzites as well as their slates and arkoses have been superimposed. The microscopic picture of the quartzites in question, however, is rather young, even if their very bottom-strata remind one of the sub-Loosian upper quartzites. The quartz grains are fully recrystallized, the only important accessory mineral being recrystallized sericite in the interstices. The recrystallization may be altogether due to the proximity of the Rätan granite, and this supposition is confirmed by the W. outcrops of the quartzite area half-way between Råberg and the main road, as well as in the Älgknopparna Hills, farther N.

The texture of the quartzite in those exposures is much less recrystallized, even the primary boundaries of the quartz grains being sometimes quite evident. On the other hand, the light gray to pure white colour of the rocks is, megascopically, not in agreement either with the upper of the lower Loos-quartzites. The white sub-Loosian top quartzites are actually more in correspondance with the crystallized parts of the Råberg quartzite, while the W. types remind one of the

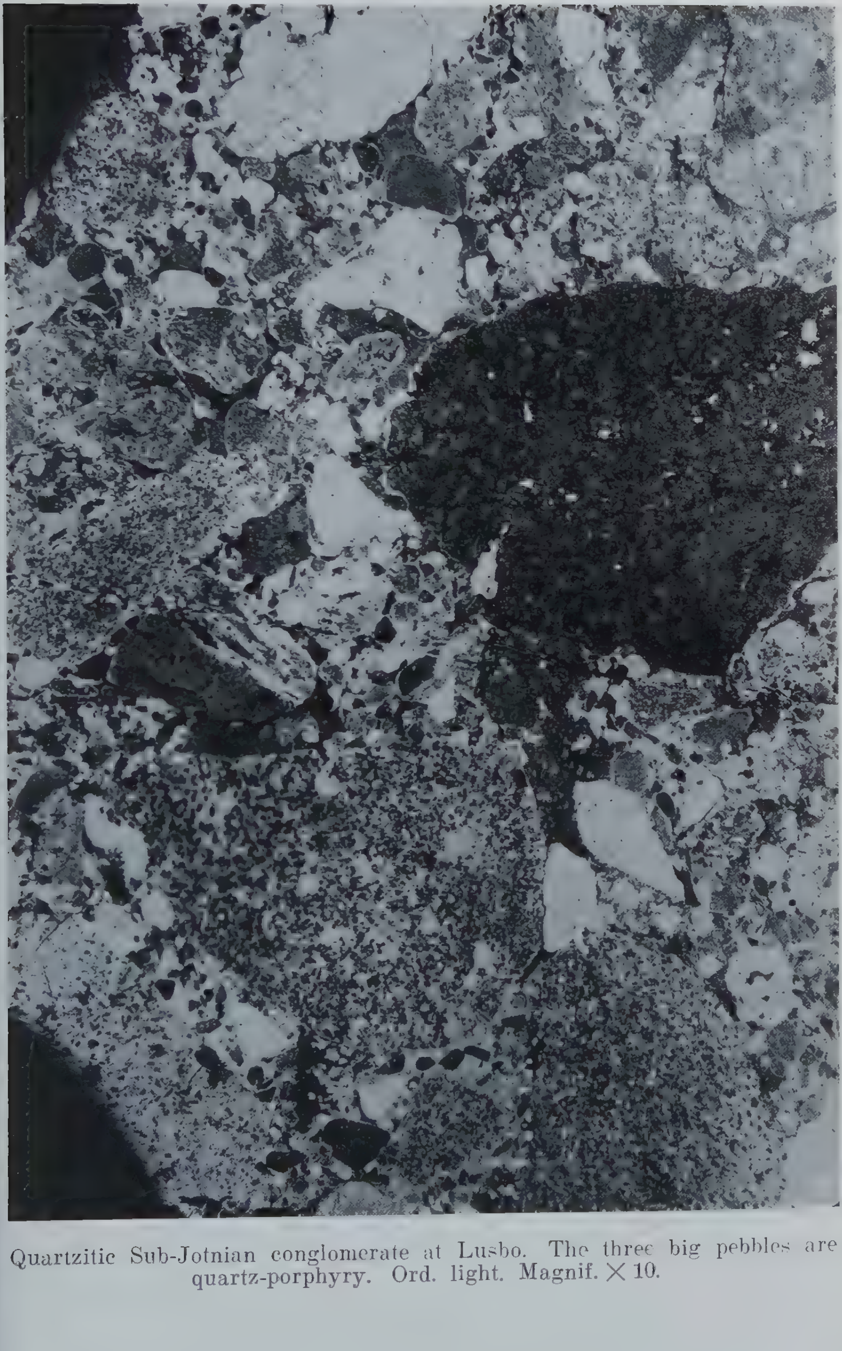
Noppi series. It may, of course, be possible that the bottom quartzite at Ö. Råberg is of sub-Loosian age, while the upper quartzite may be even Noppian. For the present, however, they have been mapped as Loosian and their tectonically puzzling position left to future research.

The Noppi Series.

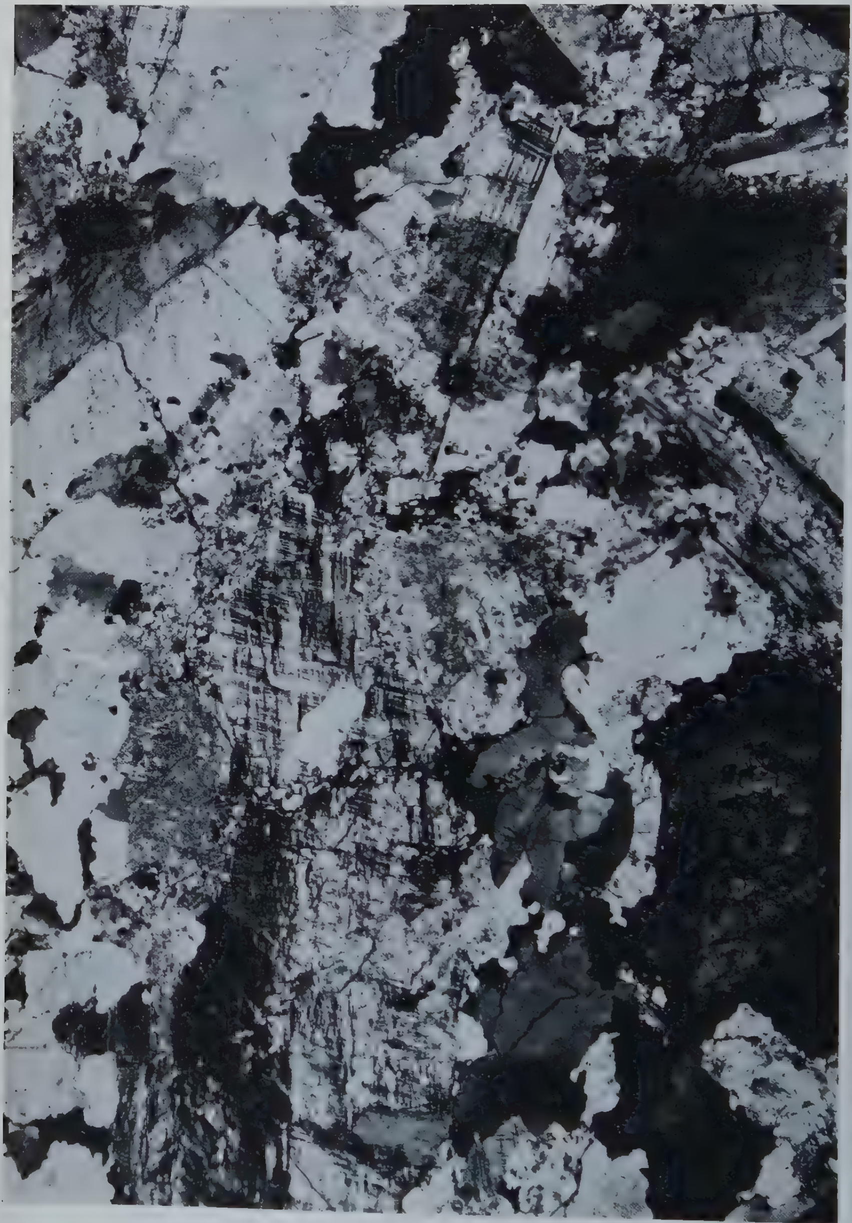
The Basal Conglomerate.

Finally, there remain to be mentioned the sandstone quartzites immediately underbedding the Noppi quartz-porphyries. This quartzite is, microscopically, almost arkosic, the grains being unevenly assorted and sometimes rather angular. At places, the rock assumes a perfectly white colour with well-developed current bedding quite similar to that W. of Ö. Råberg. An exposure occurs at the bend of the road immediately N. of Noppikoski while the normal reddish coarser types crops out in the river canyon below the falls. The whole formation is strikingly different from the brecciated underlying violet-gray upper Loos-quartzite of Sandsjö type, which latter encloses big fragments of the older slates (cf. Pl. LIII). The original bedding is somewhat obscured by a secondary cleavage connected with the tectonic disturbance on the intrusion of the quartz porphyry, and by the breccia dislocation. It seems, however, to be unconformable with the schists even if the angle is low. The cementation of the rock is considerably less advanced than that of the violet-gray top-quartzites and most of the original grain boundaries are still discernible. Very little recrystallisation of the primary clastic mica has taken place, except close to the porphyry contact, where it is evidently replaced by chlorite and biotite. These latter phenomena, by the way, furnish valuable confirmatory evidence of the presence of a magmatic contact. As previously inferred, the somewhat tectonic disturbance of the joint, makes the reading of the age relationship at the joint rather difficult.

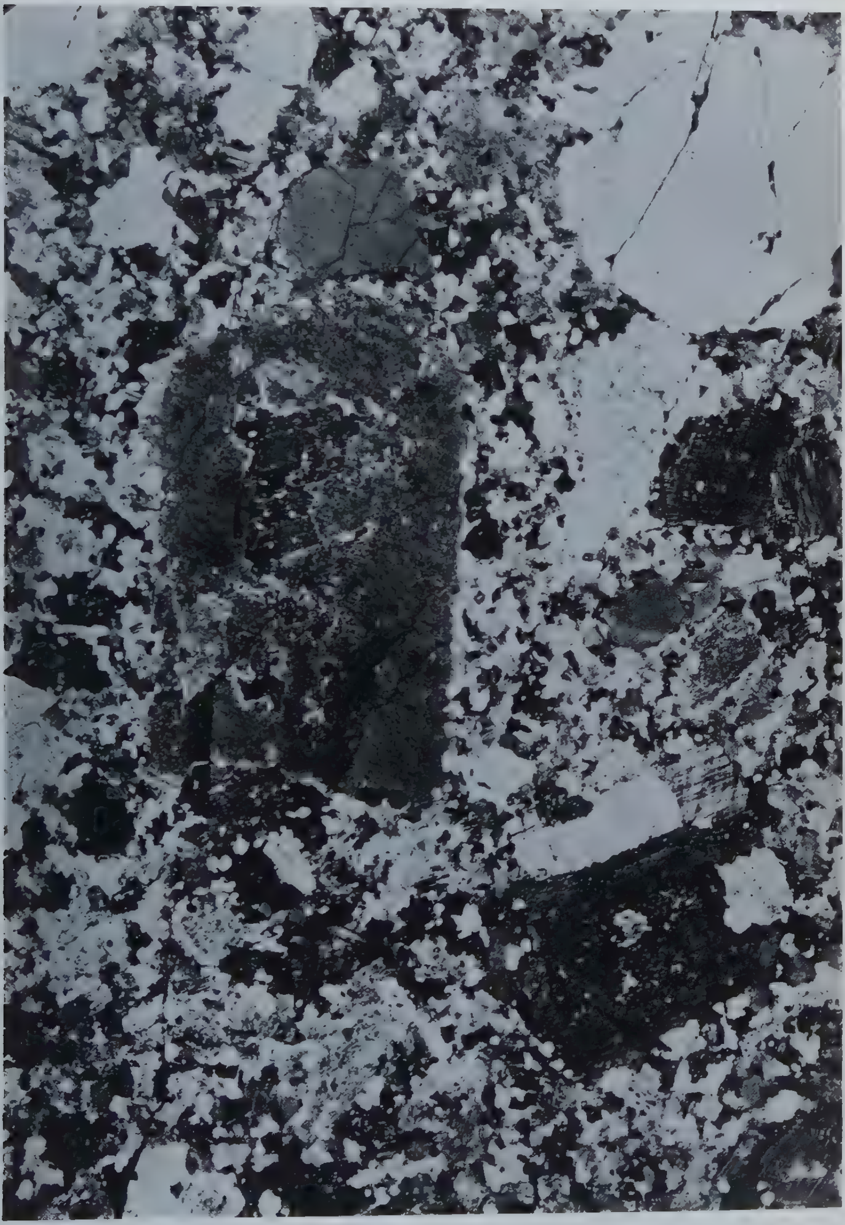
The presence of a conglomeratic zone of pebbles of older quartzite as well as granite strengthen the impression of a definite stratigraphic as well as metamorphic unconformity. This conglomeratic zone was unfortunately, blasted away last summer when the rapids were rectified in order to facilitate the timber-floating, but I managed to save a smal part in the cliffs on the S.E. side of the bridge. The writer begs his colleagues, when visiting the locality, to leave them kindly »in situ» as a piece of valuable evidence. In the chronological diagram of the writer's preliminary report, however, he placed the unconformity at the base of the Noppi quartz-porphyries, at that time not having observed



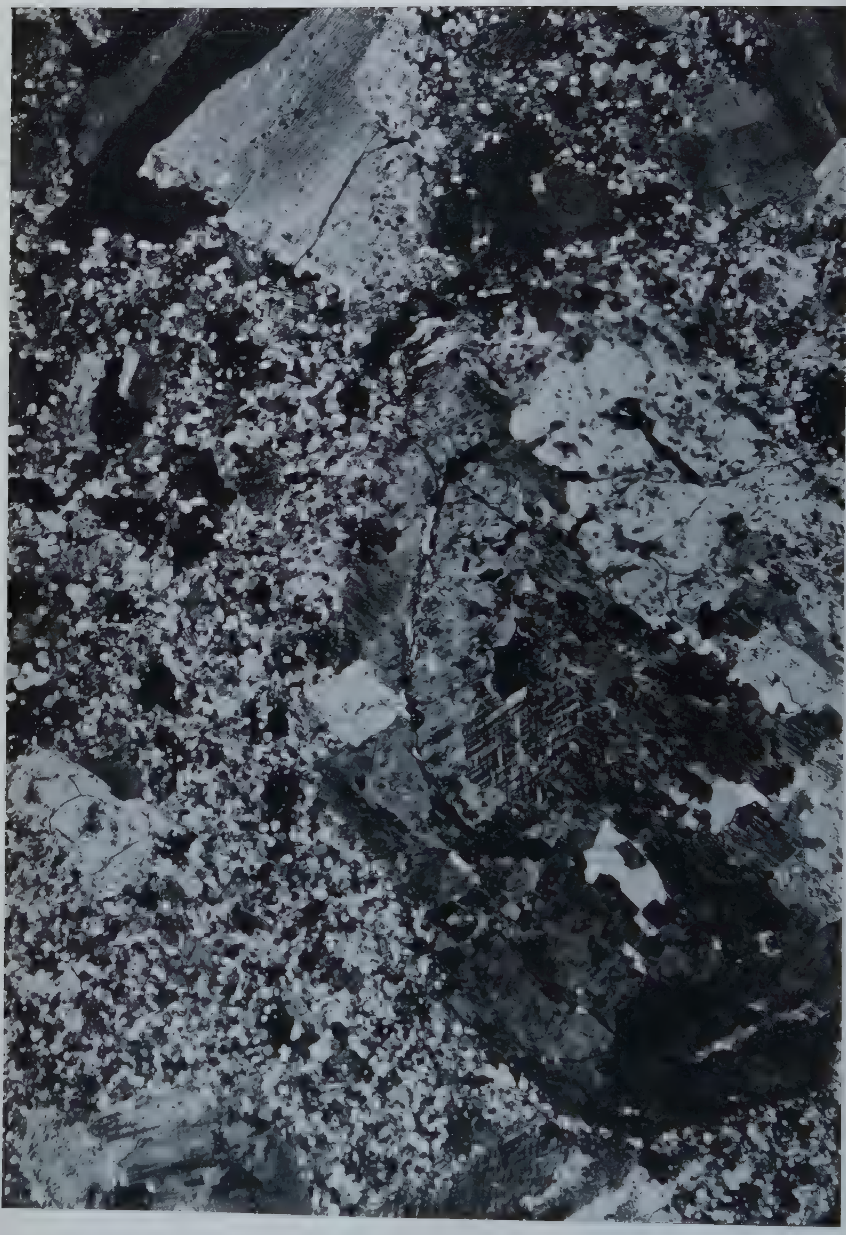
Quartzitic Sub-Jotnian conglomerate at Lusbo. The three big pebbles are quartz-porphyry. Ord. light. Magnif. × 10.



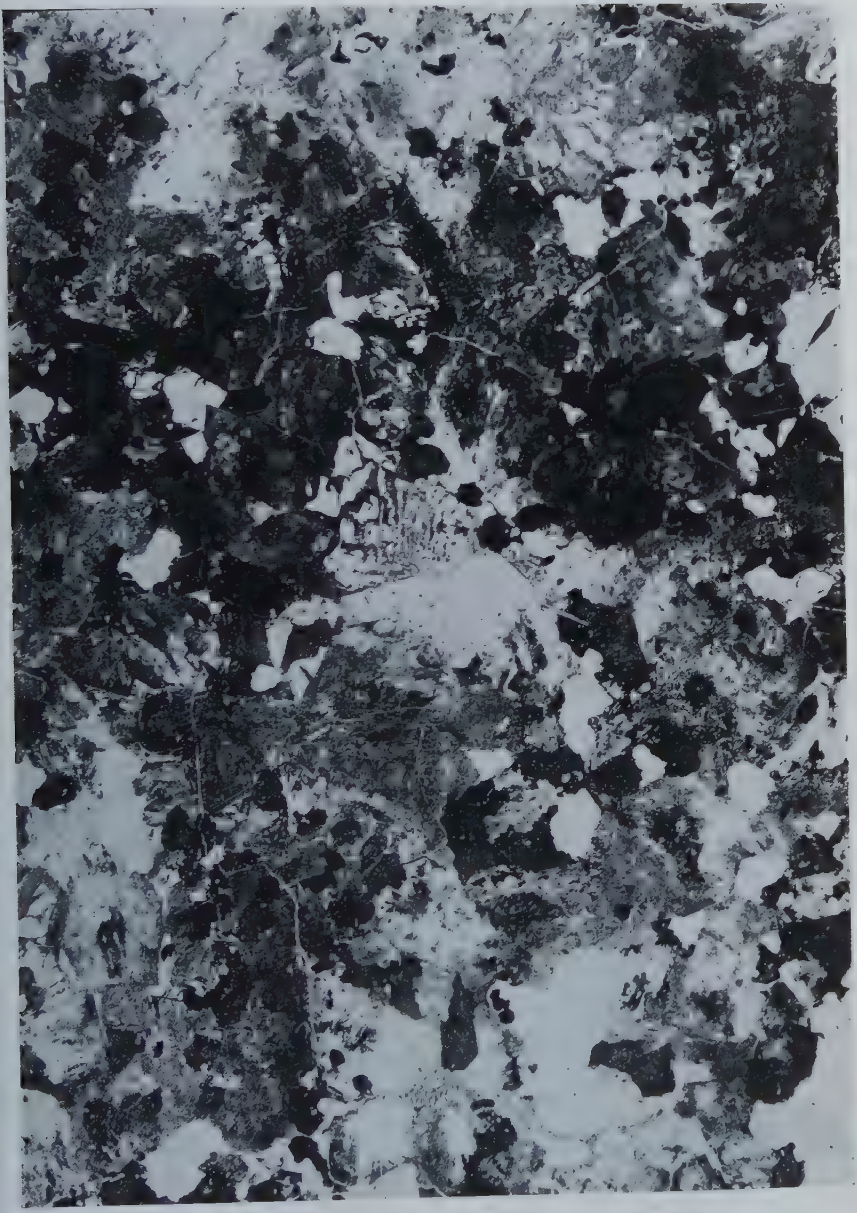
Rätan granite from the hill E of Skogs Karlsvall, north of Loos. The microcline crystal in the centre is partly surrounded by a shell of albitic oligoclase. Optically unhomogeneous quartz. Nic. +. Magnif. × 10.



Gray marginal Rätan granite, north of Loos. Nic. +. Magnif. × 10.



Rätan granite. To the right, big phenocryst with shell of oligoclase-albite surrounding microcline. Nic. +. Magnif. × 10.



Granophyric marginal Rätan granite, west of Råberg. Nic. +. Magnif. × 10.

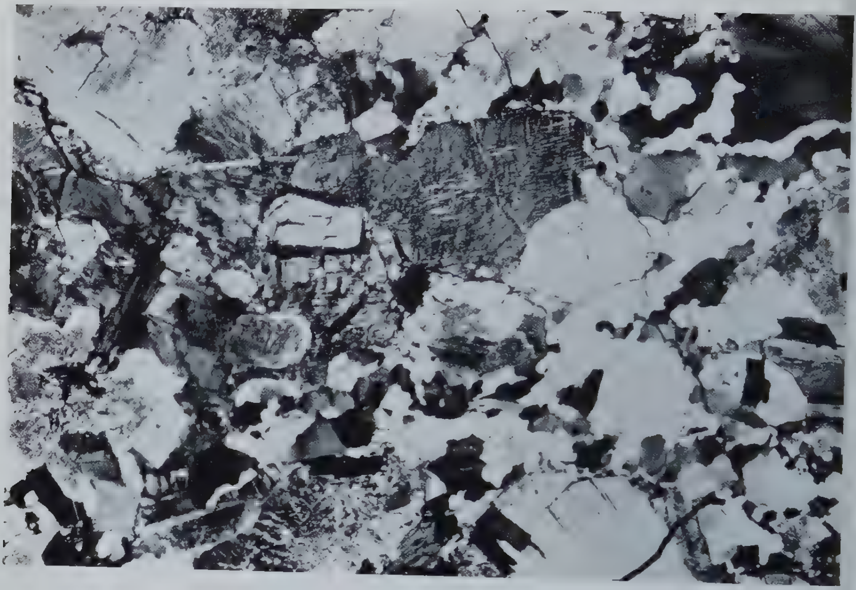


Fig. 1. Hybride-rock of Rätan- and Risberg granites. Optically unhomogeneous quartz. Nic. +. Magnif. × 10.

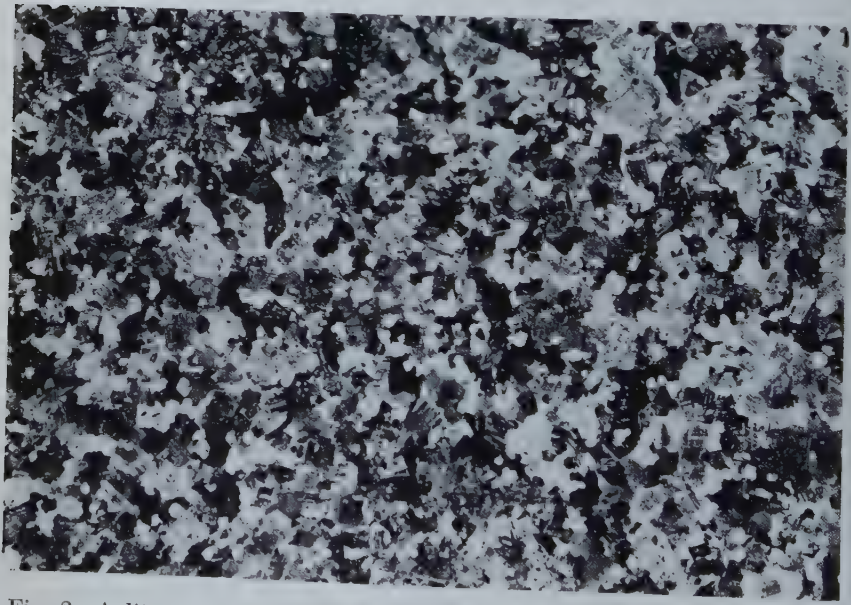
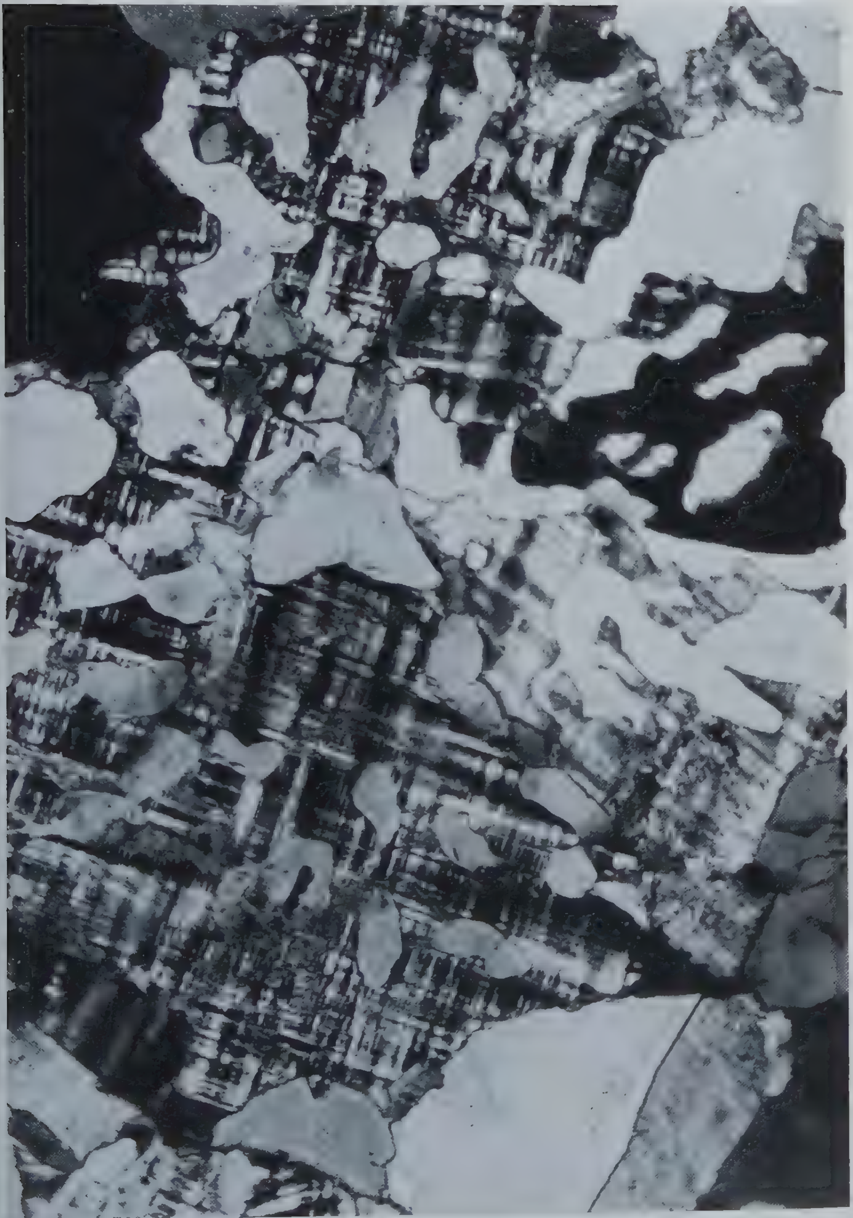


Fig. 2. Aplite of Rätan granite at Öjungshammaren. Nic. +. Magnif. × 10.



Poikilitic texture of the Rätan aplite from Klucken. Nic. +. Magnif. × 55.

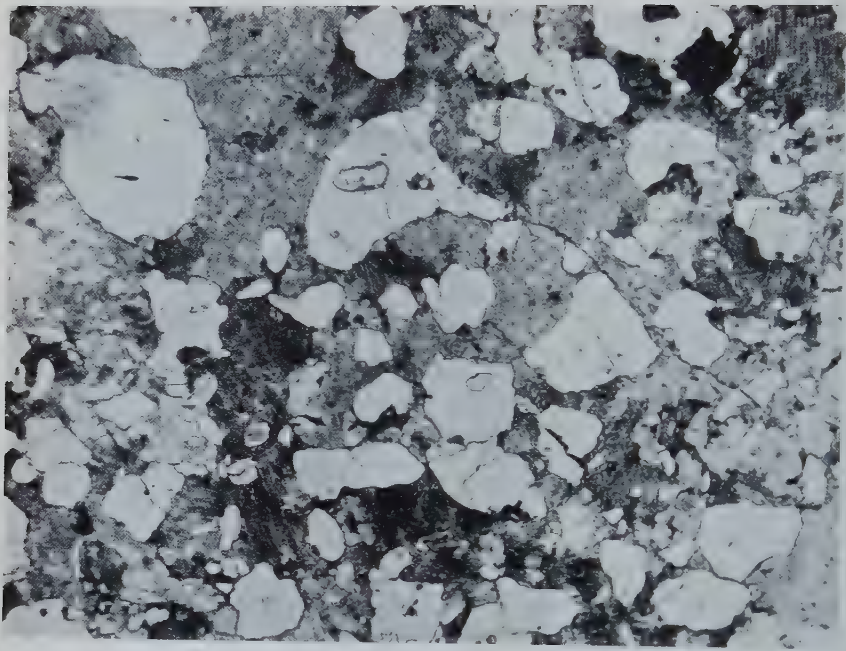


Fig. 1. Acid Rätan granite W of Lekattkölen. Ord. light. Magnif. × 35.

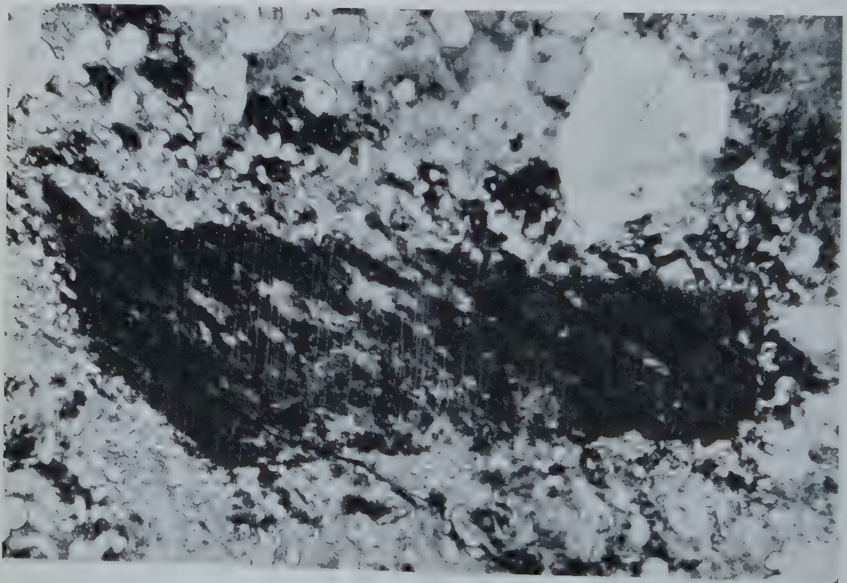


Fig. 2. Thermo-metamorphosed Rätan granite close to diabase E of Woxhalla. Coarse »milky-way»-texture surrounding microcline crystal. Ord. light. Magnif. × 25.

the discordance between the conglomeratic zone and the older quartzite. Actually, the unconformity is situated some hundred m. lower, the reddish sandstone-quartzites constituting an accumulation of detritus of the underlying quartzites and slates, already present at the time of the Noppi-porphyry extrusion (cf. Pl. LI. LII).

Consequently, the conglomerate between the Loos and Noppi series in the chronological diagram of this memoir has been moved to the position of a basal conglomerate of the latter series.

The Noppi Porphyries.

The Noppi porphyries occupy a large area around, and mainly to the south and west of, Noppikoski. Their contact with the underlying quartzitic sediments is nicely exposed east of the bridge at Noppikoski and has been described in the previous chapter. Reference has already been made to the brecciating of the grayish-violet upper quartzites of the Loos-series by the porphyries, S. of Tallsjön along the outlet of this lake. To the S., the porphyries rest direct on the arkose of the old archæan which may be studied at the small outcrop on the southern slope of Viidamäki Hill. Circling the foot of the hill, eastwards from the outcrop, one strikes the magmatic contact between the younger granite which is presumed to be of Rätan age and the porphyry — a contact already noted and described by LOOSTRÖM.

At this contact the porphyry beds rest on the archæan fairly horizontally, the maximum dip towards the N.W. being about 30°, and the bottom part being a gray felsitic rock decidedly more finely grained than at higher levels. Where the chilled and granophyric marginal border of the Rätan granite meets the porphyry, the latter gets coarser, also sometimes developing secondary granophyric textures, making it rather difficult to decide whether an outcrop consists of porphyry or of the chilled marginal phase of the granite. At several places dykes from the granite clearly intrude the quartz-porphyry. At the intrusive contacts, as well as at higher levels, the porphyry is of a reddish-brown colour.

At the Noppikoski contact, the base of the lava-flow, too, is of a gray felsitic habit, with few phenocrysts, gradually displaying an increasing amount of small quartz grains at a distance from the contact and merging into a brown rock with additional phenocrysts of red felspar at about 300 yards W. of the bridge. True felspar types, such as the Loos porphyries at Gullberget, are never observed, however, within the Noppi lavas, neither have any true vesicular effusives corresponding to the Hjärpberget rocks ever been noticed.

At Noppikoski, especially in the vicinity of the bottom contacts, the porphyry exhibits a streaky appearance not quite coinciding with the original flow structures. The streaks may be referred to differential moments at the slightly tectonized contact.

At the Autiomäki Hill, the granophyric rock separating the porphyry from the granite contains greenish-black basic inclusions, occurring at a definite stratigraphic level. Part of the latter may even show a homogeneous dark granophyric rock, no corresponding rock having been found elsewhere in solid outcrops. LOOSTRÖM, too, whose attention was drawn to these inclusions, supposed them to be fragments of an older diabase. The mother rock of the dark inclusions, as well as the homogenous dark fragments, both consist of a nicely granophyric rock where more or less coarsely lath-shaped and twinned oligoclase crystals and tabular microcline-crystals constitute the bulk of the texture of quartz; green hornblende, a large percentage of ilmenite, allanite and a sparse ground-mass of felspar and quartz in poikilitic intergrowth, making up the balance. In the inclusions, the same femic minerals predominate over the acid, but the mineral composition is the same. The texture of the mother rock being somewhat inhomogenous, it has every aspect of resulting from contamination of the granitic or porphyric magma by an earlier basic extrusion of the same magma; part of the earlier inclusions, being already absorbed by the ascending acid differentiates.

On the N.E. slopes of Autiomäki and at Millberget even flows of decidedly porphyric character with nicely preserved primary flow textures have been found to contain these inclusions as well as fluxed streaks of them, rich in amphibole and titanite.

The less metamorphosed inclusions carry all the hall marks of the Rätan granite, their titanite, hornblende and violet fluorite being similar. They may be taken as the Noppi counterpart of the greenstones of the Loos-series, preceding the extrusion of the acid lava.

In this connection, reference may be made to the earlier supposition that the Noppi porphyry sediments, as suggested by LOOSTRÖM, are contemporaneous with the lower Loos-series. During the first years of his work in the region, the present author was labouring under the same delusion but found it increasingly difficult to make the field evidences fit this hypothesis. During a long period he regarded the Noppi sedimental pack, E. of Noppikoski, as an overturned fold of Loos sediments, assigning the better preserved primary features of the Noppi period to a lesser degree of metamorphism. Having at last to give way to the accumulating contradictory evidence, he still for a long time entertained strong doubts as to the correctness of his deductions. The points of evidence which finally clinched the matter, however, were the following:

1) The undisputable »younging» of the Noppi sediments towards the porphyry, as evidenced by the beautiful current bedding.

2) The occurrence of easily recognized violet-gray quartzite of the younger Loos-series within the magmatic breccia of the Noppi quartz-porphyries at the Tallsjö brook.

3) The stratigraphic succession at the same brook, to be discussed later, and

4) The consanguinity between the earlier basic members of the Noppi extrusion, their succeeding acid ones and their parent magma, the Rätan granite, on one hand, and the deficiency of any relationship of these rocks and the Loos lavas and Risberg granite, on the other.

The chemical and mineralogical range of composition of the quartz-porphyries are fairly similar, however, within the two age-groups, as demonstrated by the appended analyses No. 59—61 and by their modes.

The plagioclase ranges from An_{24} in the slightly granophyric quartz-porphyry, S. of Kvarnberget, to almost pure albite An_{2-4}, in the more acid quartz porphyries at Noppikoski and Tallsjö Lake. The potash felspar is, presumably, originally perthitic orthoclase, changing into microcline in agreement with the degree of dynamical stress imposed on the rocks.

A calculation, based on the analysis and geometric measurements, shows that most of the albite occurs as phenocrysts, only about 20 % remaining in the ground mass. The former are about 2—6 % richer in anorthite than the plagioclase of the latter.

Secondary biotite was found within the thermally metamorphosed aurole of the Rätan granite, while secondary chlorite is fairly common within the rocks, caught in the great dislocation zone E. of Noppikoski as well as in the streaky parts of the base of the lavas at Noppikoski bridge. The quartz phenocrysts are of undular extension and the felspar phenocrysts shattered within the dynamically metamorphosed areas, otherwise they are homogenous and only protoclastically broken. The beautiful behexaedral quartz phenocrysts as well as the felspars are sometimes corroded and embedded in a well-preserved fluidal base. Sericite is generally abundant within the micropoikilitic ground mass but may very well be entirely absent in dynamically unaffected places, such as the very peak of the Noppimäki hillock, a conspicuous monadnock, dominating the landscape S. of Noppikoski (cf. Pl. CIII, Fig. 1).

Another well-preserved area is the Ormtjärnsknoppen Hill within the raised area S. of Älvho, where the spongily micropoikilitic base displays

Analysis Nr. 59.

Quartz-Porphyry, two miles south of Kvarnberg (Ls - 502).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	72.40	120.55	Q 34.48	Quartz 32.7	qz +175	s 79.5
TiO_2	0.55	0.69	Or 28.40	Orthoclase (Microcline) 26.1	si 391	A 6.2
P_2O_5	0.12	0.09	Ab 20.56	Plagioclase ($Ab_{76}An_{24}$) 27.0	ti 2.24	C 1.5
Al_2O_3	11.95	11.72	An 6.91	Chlorite and some Biotite 10.8	al 38.0	F 4.9
Fe_2O_3	1.37	0.86	C 0.20	Ores 3.2	fm 24.5	a 15.0
FeO	3.16	4.40	Σ sal 90.55	Apatite 0.2	c 8.5	c 3.5
MnO	0.09	0.13	Hy 5.13	100.0	alk 29.0	f 11 5
MgO	0.51	1.27	Mt 2.02		mg 0.17	n 4.3
CaO	1.44	2.57	Ilm 1.05		k 0.57	k 1.76
Na_2O	2.43	3.92	Ap 0.20		c/fm 0.85	
K_2O	4.82	5.12	Σ fem 8.40			
$H_2O^{+105°}$	0.88	4.89	H_2O 0.88			
			99.83			
$H_2O^{-105°}$	0.12					
	99.84					

Quantitative System: I: 3: 2: 3 — *Tehamose.*
Osann's Type: No. 14. Macomer (s 78.5, a 17.5, c 4.0, f 8.5,
n 5.4, k 1.55).
Or: Ab: An — 51.01: 36.93: 12.06.
Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.571.

Analysis Nr. 60.

Red Quartz-Porphyry from Noppikoski (Ls - v - 106).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	74.44	123.94	Q 35.44	Microcline 39.3	qz +194	s 81
TiO_2	0.15	0.19	Or 40.07	Quartz 34.9	si 450	A 7.3
P_2O_5	0.25	0.18	Ab 18.32	Albite 18.2	ti 0.72	C 0.3
Al_2O_3	11.92	11.69	C 1.02	Ores and pigmentation 3.6	al 42.5	F 3.7
Fe_2O_3	2.74	1.72	Σ sal 94.85	Sericitic Mica 3.4	fm 16.5	a 19
FeO	0.29	0.40	Hy 0.69	Apatite 0.6	c 2.0	c 1
MnO	0.02	0.02	Mt 0.46	100.0	alk 39.0	f 10
MgO	0.27	0.67	Hm 2.42		mg 0.15	n 3.3
CaO	0.34	0.61	Ilm 0.30		k 0.68	k 1.68
Na_2O	2.14	3.45	Ap 0.59		c/fm 0.14	
K_2O	6.78	7.20	Σ fem 4.46			
H_2O^{+105}	0.37	2.05	H_2O 0.37			
			99.68			
H_2O^{-105}	0.13					
	99.84					

Quantitative System: I: 3: 1: 2 — *Magdeburgose.*
Osann's Type: No. 3. Costa Zaneti (s 78.5, a 20.5, c 0.5, f 9.0,
n 6.4, k 1.42).
Or: Ab: An — 68.63: 31.37: 0.
Sp. gravity $\frac{16^\circ}{4^\circ}$ C = 2.578.

Analysis Nr. 61.

Brownish-yellow Quartz-Porphyry. S. E. of Tallsjö Lake (Ls - v - 249).

Analyst: R. Blix.)

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	78.71	131.05	Q . . 50.45	Quartz . . . 50.4	qz +326	s 83.3
TiO_2	0.07	0.09	Or . . 28.89	Mica 21.1	si 552	A 6.9
P_2O_5	no tr.	—	Ab . . 11.56	Orthoclase or	ti 0.42	C 0.5
Al_2O_3	11.39	11.17	An . . 1.09	Microcline . 16.7	al 50.0	F 2.3
Fe_2O_3	0.93	0.58	C . . 3.47	Albite 11.8	fm 16.5	a 22.0
FeO	0.40	0.56	Σ sal . 95.46	100.0	c 2.0	c 0.5
MnO	0.01	0.01	Hy . . 1.91		alk 31.5	f 7.5
MgO	0.77	1.91	Mt . . 1.20		mg 0.49	n 3.0
CaO	0.20	0.36	Hm . 0.15		k 0.70	k 1.88
Na_2O	1.37	2.21	Ilm . 0.13		c/fm 0.10	
K_2O	4.85	5.15	Σ fem 3.39			
H_2O^{+105}	1.03	5.72	H_2O . 1.03			
			99.88			
$H_2O^{-105°}$	0.17					
	99.90					

Quantitative System: I: 3: 1: 2 — *Magdeburgose.*

Osann's Type: No. 2. Paisano Mt. (s 80.5, a 23, c 0, f 7, n 6.4, k 1.56).

Or: Ab: An — 69.55: 27.82: 2.63.

Sp. gravity $\frac{20°}{4°}$ C = 2.561.

striking zones of acicular quartz around the homogeneous quartz phenocrysts. At other places these zones grade into extremely fine-textured granophyric borders. This type of quartz was described originally by HEDSTRÖM in 1894 from the so-called Baltic quartz-porphyry boulders, believed to have been derived from the bottom of the sea. He called it needle-quartz, and it has lately been further investigated by ESKOLA and TEITTINEN. Their description agrees in every respect with the Noppi rocks, and a striking similarity has been noted between the Finnish boulder of Baltic quartz-porphyry investigated by ESKOLA (Compte rendu de la Soc. Geol. de Finlande No. 8, 1934) and the Noppi porphyries. This is especially the case with No. 3 boulder (Loc. Cit. pp. 114—118), the analysis of which, as well as the texture and mineral composition, is almost the exact counterpart of the Noppi porphyries down to the FeO : Fe_2O_3-ratio. A comparison between ESKOLA's microphoto No. 2 and the one appended (Pl. LIV) to this memoir further illustrates the fact.

One will, therefore, be on fairly safe ground when suggesting that the sub-Baltic quartz porphyry is of Noppi age and older than the intrusion of the Rapakivi granites. The poikilitic, or rather micro-poikilitic texture, of the ground mass needs no further elucidation, reference being made to GEIJER's admirable description of 1913 which fully applies to this case.

Returning to the analyses, the increase of excess alumina, accompanying the increase of silica and expressed in the norm in terms of carborundum, is worth emphasizing. The same phenomenon was earlier pointed out in these pages when discussing the Loos porphyries.

Mineralogically, all this alumina enters the sercitic mica, and the simple mineral composition of the quartz-porphyry S.E. of Tallsjö lake permits a fairly accurate calculation of the composition of the mineral in question.

If it is computed as a phengite, there will still be an excess of alumina, and if it is taken as a sericite, there will be an almost equal deficiency in alumina.

The calculated composition is given below:

SiO_2	46.5 %
Al_2O_3	28.4 »
Fe_2O_3	3.9 »
FeO	1.7 »
MnO	0.0 »
MgO	3.2 »
CaO	0.8 »
K_2O	11.2 »
H_2O	4.3 »
	100.0 %

This analysis corresponds to about 50 % phengite- and 50 % sericite-molecules.

This high alumina-ratio of the quartz-porphyries is certainly puzzling and is, in a way, a warning not to ascribe »a priori» a sedimentary origin to highly metamorphosed rocks, possessing no primary magmatic features, but rich in alumina. This warning may also be extended in regard to magmatic rocks of an unusually high alumina content, where contamination by aluminous sediments in many cases has been used as an easy explanation.

The volatiles of injecting granites may, in local cases, be to some extent partly responsible for a secondary enrichment in alumina through the carrying away of other compounds, but such local changes can certainly not be connected with the regional character (in space as well as time) of the phenomena encountered by the quartz-porphyries, irrespective of the chemical composition of their parent magmas.

This feature, recurring at enormous intervals — which, as will be seen in the later pages of this paper, is repeated in the Dala porphyries too, —

strongly indicates some other agencies at work. As the alumina excess is bound only to the strictly volcanic effusive rocks and is absent in their deep-seated parent magmas, it may be supposed to be intimately connected with the release of hydrostatic pressure within the magmas rather than with a normal differentiation sequence of the magma itself.

The author, consequently, ventures to suggest, as a possible explanation, the escape of alkali together with high tension-volatiles, liberated at the decrease of pressure following upon the extrusion of the lavas on to the surface of the earth. This would lead to a concentration of alumina, either suspended within the volcanic glass and later on, on devitrification, entering the phengitic mica, or else crystallizing as such on the cooling of the lava flows.

Even the Rätan magma must, in spite of its lack of pegmatites, have contained a noticeable amount of volatiles, as shown by the regular content of fluorite. This latter mineral is also found occasionally within the Noppi porphyries, and the rock of analysis No. 61 especially contains it, both as a »perthitic» replacement intergrowth within the felspar phenocrysts and also in the shape of sporadic grains within the ground mass. Where this quartz porphyry is brecciated, S.E. of Tallsjö, the breccia veins mostly consist of fluorite. This brecciating follows strictly, and almost like a banding, the bedding-planes of the lava and may have resulted from differential movements during the cooling period, although it may also be connected with the later fault which passes through the quartz immediately to the E. In either case, the fluorite may be supposed to be derived from the quartz porphyry.

Finally, a few words may be said respecting the tuffitic rocks connected with the Noppi-porphyries. No analyses have been made of these rocks, but they are exponents of typical »hälleflintas». The tuffs north of Gråtbäck Stn. are partly unmistakable acid ash-tuffs, but in some localities along the fault they are so strongly dynamically metamorphosed that the presence of a primarily volcanic rock may not be altogether excluded.

The rocks are always felsitic with megascopically conspicuous small dark quartz-grains.

The Noppi Sediments.

The primary features of the Noppi sediments are generally very much better preserved than those of the Loos sediments, and their metamorphic state is far less advanced. Their geomorphic succession is about the same as the previous one, although the erosion has not broken down the rocks to the same degree as in pre-Noppi time. The erosion period seems to have been shorter, or the peculiarities of the climate different, the quartzites and graywackes generally being coarser and no »varved» pure slates of the Loos-type occurring (cf. Pl. LV).

The lower quartzites, to which reference has already been made when discussing the upper Loos quartzites, are not very thick anywhere. In the large area W. of Kvarnberg and Noppimäki one would expect them to crop out underneath the steeply tilted sediments W. of the big fault. Tuffitic hälleflintas, instead, directly oppose the porphyries E. of the fault. These tuffs grade westwards directly into schists which does not, of course, exclude the possibility of the bottom arkose being cut out by the fault.

In the Tallsjöbäcken district, the brecciated gray-violet upper quartzite of the Loos-series is overlain unconformably by a very heavy conglomerate of older rocks, nicely exposed in the river bed and grading upwards into a yellow sandstone-quartzite of some 50—100 m. thickness, covered by quartz-porphyries. This is an exact repetition of the succession at Noppikoski, only that the basal conglomerate is more strikingly developed. On top of the quartz porphyry follows, without any sign of weathering, the same quartzite again, indicating the intrusive character of the lava-sheet. In other localities, however, such as for instance S.E. of Tallsjö Lake, the quartz-porphyry has a more distinctly effusive character and seems to have congealed on the surface. The same seems to have been the case farther S. at Oreälven where the contact between the upper red Noppi-porphyry and a remaining part of the quartzite spared by erosion shows big fragments and chunks of the porphyry within the basal parts of the sediment.

The Noppi-porphyry, consequently, has apparently been intruded along the bedding of the lower quartzites as well as extruded on top. The descending succession, consequently, is as follows:

Youngest:	Basal conglomerate of the Dala series.
	Yellowish-white quartzites.
	Quartz banded slates.
	Graywackes.
	Tuffitic graywackes.
	Quartz-porphyry.
	Reddish or white quartzite.
Oldest:	Basal conglomerate.

Within the extensive southern Noppi area, the bottom quartzite may, consequently, be looked for, not only at the fault but also at the base of the porphyries at Viidamäki, where however, it does not exist, being replaced by the arkose of the old gneiss granite. The whole series of slates and graywackes may be absent, as seems to be the case W. of Noppikoski along the Oreälv river. On the other hand, they occupy a very prominent position in the subsided area S. of Älvho (in this connection, the subsidation is mentioned in relation to the quartz porphyries; in comparison with the Dala series it is, of course, a case of up-lift).

The tuffitic graywackes are generally rich in titano-magnitite ores and fragments of porphyry. They grade into more evenly assorted quartzose graywackes, in which the felspar fragments are always quite fresh. The diminishing of the grain-size carries the rock into slaty types, but actually the Noppi slates are never anything but fine-grained graywackes. This slaty rock alternates with dark gray, microscopically pebbly quartzites.

The grains of all the members of the Noppi series, except the last dense quartzite, are always very angular and, as already intimated, have evidently not taken part in any long epoch of erosion (cf. Pl. LV, Fig. 2). This constitutes one of the greatest differences from the Loos-series and a very important one, too, as it deals with a feature which could hardly have been obliterated on the metamorphism of the Loos-series. If, as previously assumed by earlier investigators, they had been contemporaneous, this difference could not have occurred. An additional support is added by the evidence of primary geomorphic features, such as ripple marks and sun-cracks, already dealt with in a previous chapter (Pl. LVI, Fig. 2).

Another great difference between the two series lies in the mineral constituents. Analyses Nos. 62 and 63, both taken from the slates of the, dynamically, worst ill treated area S. of Älvho, are illuminating. Besides slightly optically unhomogeneous quartz, phengitic sericite is the only principal constituent, the accessories being some albite, apatite and titanomagnetite. The tuffitic graywackes also contain some chlorite, undoubtedly derived from the sometimes rather common occurrence of this mineral with the porphyries. In no case — except occasionally at Korpimäki close to the Rätan granite — has any biotite been found, which constitutes a striking contrast to the metamorphic phase of the Loos-series.

If a comparison from a metamorphic point of view had to be made across the whole distance between Noppikoski and Loos, the phase-difference might lose some of its evidential value, but the distance being only about a mile or two between the Noppi-series at Tallsjöbäcken and the Loos-series at Oreälven, strong support is given to the

Analysis Nr. 62.

Quartz-pebbly Slate. Brynberget. (Ls - v - 496 b.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Actual mineral composition %	Niggli's ref. values
SiO_2	77.76	129.47	Quartz 61.8	si 506
TiO_2	0.16	0.20	Mica (Sericitic) . . 37.0	qz . . . +332
P_2O_5	0.00	—	Ores 1.2	ti 0.89
Al_2O_3	11.06	10.85	100.0	al 48.5
Fe_2O_3	4.71	2.95		fm . . . 33.0
FeO	0.46	0.64		c 0.0
MnO	tr.	—		alk . . . 18.5
MgO	0.35	0.87		mg . . . 0.15
CaO	0.00	—		k 1.00
Na_2O	0.00	—		c/fm . . . 0.0
K_2O	3.88	4.12		
H_2O^{+105}	1.63	9.05		
H_2O^{-105}	0.22	—		
	100.24	Sp. gravity $^{20°}_{4°}$ C = 2.750.		

Analysis Nr. 63.

Black Slate. Lekattkölen Hill, Åmån. (Ls - s - 57.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Actual mineral composition %	Niggli's ref. values
SiO_2	73.59	122.53	Quartz 63.9	qz . . . +258
TiO_2	0.20	0.25	Sericitic Mica (with	si 404
P_2O_5	0.08	0.06	ore interpositions) 32.7	ti 0.87
Al_2O_3	9.71	9.53	Albite 3.2	al 33.0
Fe_2O_3	8.16	5.11	Apatite 0.2	fm . . . 55.0
FeO	2.39	3.33	100.0	c 0.5
MnO	0.04	0.06		alk . . . 11.5
MgO	0.88	2.11		mg . . . 0.14
CaO	0.08	0.14		k 0.82
Na_2O	0.35	0.57		c/fm . . . 0.01
K_2O	2.52	2.68		
$H_2O^{+105°}$	1.74	9.66		
$H_2O^{-105°}$	0.19	Sp. gravity $^{20°}_{4°}$ C = 2.764.		
	99.93			

chronological sequence of the two series, advocated in the present memoir.

Finally, a few words have to be said respecting the upper quartzites of the Noppi-series immediately underbedding the unconformable top-conglomerate, viz, the basal conglomerate of the Dala-series. It is a well-sorted pelitic sediment (size of grains about 0.3 mm.) with nicely preserved primary grain-boundaries and a matrix of phengitic sericite. A characteristic feature is the presence of an unusual amount of pyrite grains among the mica. Current bedding is nicely in evidence and there is no question as to which way the rock is »younging».

The Rätan Granite.

The Rätan granite occupies a large mountainous area of about 50 Swedish sq.miles (1 000 English sq.m.) of which only a small part falls within the northern district of the appended map. It derives its name from a locality within the province of Härjedalen, from which place it was cursorily described by Högbom in a memoir of 1894 (17) and it was later referred to by Blomberg in 1905 (1). Both emphasize its very constant composition over the entire area.

The age of this granite has been the subject of some discussion. While Blomberg considered it old archæan but younger than the oldest gneiss granites, which it was stated to brecciate along the eastern boundary N. of the present map, Högbom pointed out the similarity of its marginal phases to the Garberg granite of Dalecarlia which he considered to be younger, however. In his outstanding memoir on Norrland, 1906 (15) he actually puts the Rätan granite in relationship to the Dala porphyries, considering them to be younger than the Loos porphyries. At the same time, however, influenced by the conception ruling in those days, he ascribed them to an earlier age than the so-called »ser-archæan» Revsund granite. This latter granite he considered contemporaneous with the Stockholm granite.

In his contribution to the »Handbuch der Regionalen Geologie» (16) Högbom has changed his view and regards the Rätan granite as younger than Stockholm granite, still maintaining, however, a close connection with the Dala-porphyries as well as with the identical Siljan granites but at the same time ascribing to them an older age than the Rapakivi granites. On this latter point he took the opposite view to Sederholm who, in the meantime, had referred the Dala Porphyries to the Rapakivi group.

Högbom's opinion has also been the »official» Swedish view, upheld since then and recently expressed anew on the Geological map of Sweden, published last year under the supervision of Mr. Axel Gavelin, General Director of the Geological Survey. Sederholm, on the other hand, after having taken note of the preliminary result of the present author's investigations, in his last important paper in 1932 on the correlation of the pre-Cambrian rocks of Fenno-Scandia retained his old opinion that the Rapakivi granites and the Dala porphyries were contemporaneous. Agreeing with the writer's views, he assigned the

Rätan and Siljan granites to a minor epoch of diastrophism preceding the great unconformity underlying the Dala series.

The present writer's chronological sequence is based on very strong evidence in the field as well as on laboratory work. Directly observable contacts between the Rätan granite and the adjoining rock are few but of great importance. The Rätan granite brecciates the old magmatites within a limited area E. of Romberg, where beautiful exposures are found on the E. side of the Sättnäsån brook N. of the lake. The chemical influence, however, is slight, xenolithes of migmatite mainly being subjected to thermal metamorphism. The granite cuts the sub-Loosian schists, too, at Raisberget and Öv. Hamravallen, with very sharp contacts and slight brecciation.

Its younger age, as compared with the Loos-series, is verified by well-preserved greenstone inclusions in several localities along the northern border of the greenstone area and also by the big xenolithe of greenstone submerged in the granite magma N.E. of Tansjö. It also clearly cuts and penetrates the Loosian acid tuffites and quartzites S.E. of Tansjö, in the Toberget Hills.

Turning to the Noppi porphyries, reference has previously been made to the Rätan granite's exhibiting chilled borders at the contacts towards these porphyries, and even intruding between the lava flows, whereas the granite displays an increasingly aplitic marginal phase towards the Loos quartzites of the Sandsjö ridge. On the other hand, the granite shows a very coarse grain close to the porphyries and diabases at Röstknoppen S. of Lillhamra.

Even if the actual contacts in these two cases are not exposed, their probable distance from the outcrops must be about the same and, consequently, an older age of the granite as compared with the porphyries and diabases is clearly indicated.

No undisturbed joints between the Rätan granite and the Noppi-sediments have been observed, but an aplitic chilled zone of the granite area towards the fault, E. of Lusbo and Myggsjön and separating it from the subsided area of Noppi-rocks, leaves no doubt of an original magmatic contact. As the basal conglomerate of the lower Dala series is deposited unconformably on top of the granite and as the granite also bears signs of strong dynamic stress, thus contrasting with the dynamically unaffected lower Dala-series, no other primary contact but the one between the Rätan granite and the block of Noppi sediments is possible.

What remains undecided, however, is whether the original contact was made between Rätan-granite and Noppi-sediments or between the Rätan-granite and Noppi-porphyries or even the underbedding rocks. This depends on the vertical measure of the downthrow at the fault.

Some indication might have been gained from a comparison between the topographic levels of the Rätan-granite of Lusbo and of that E. of Kvarnberg, — but for the uplift of the Noppi-plug. The former granite owns its present position to this jotnian movement, and no comparison could be undertaken without knowing the extension of the latter dislocation.

As there is no evidence permitting of even a reasonable guess, the »ceiling» of the Rätan-granite within the Noppi-succession is, consequently, left undetermined. It may intersect the sediments, — and it may not.

Turning to younger strata a big boulder of Rätan granite of several m³ was observed last year within the inter-Jotnian conglomerates at Bössfallet when a new channel was blasted through the rocks in order to facilitate the timber floating. This definitely limits the age of the Rätan granite upwards and rules out the old conception of the Rätan granite being contemporaneous with the Rapakivi granites (cf. Pl. CII, Fig. 1).

The Rätan granite is a rather coarse syenitic, somewhat porphyric rock, containing up to 3—4 cm.-large pink perthitic Karlsbader-twins of microcline and some white oligoclase phenocrysts within an equigranular base of the two felspars, a grayish violet vitreous quartz, brown biotite, titanite and green hornblende, the latter sometimes containing cores of pyroxene. Common accessories are magnetite, apatite, zircon and fluorite. The rock weathers easily, being in this respect strangely similar to the Finnish Rapakivi granite. Its texture on polished surface, showing darkly coloured quartz grains surrounding the big felspar phenocrysts, strongly reminds one of the »pyterlite-Rapakivi» described by Wahl (36).

The microcline crystals are sometimes rectangular but are mostly rounded and occasionally surrounded by myrmekitic or homogeneous zones of plagioclase (An_{14}), showing on fractures rock surfaces as narrow white shells around the pink potassic kernels (cf. Pl. LVIII). This Rapakivi-like textural feature seems to be bound to the more acid marginal phases, and is very rare. An interesting case of »fluorite-perthitisations» of the microcline is, on the other hand, quite common at moderate distances from the borders of the granite area. The yellow fluorite has undoubtedly replaced the plagioclase-strings within the potassic felspar by a concentration of volatiles during the late magmatic stage. At the same time, the amount of violet fluorite increases in the interstices of the ground mass.

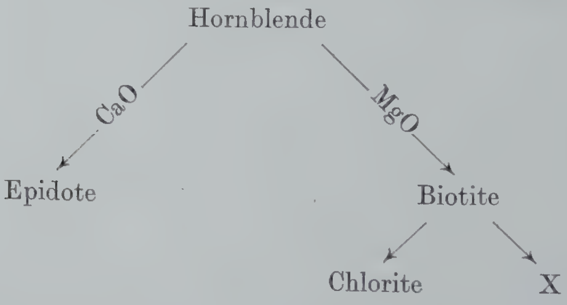
The normal type of the rock generally shows microcline shells surrounding the older homogeneous or antiperthitic plagioclase, sometimes with a thin ridge of interposed myrmikite. Towards the contacts, the plagioclase becomes distinctly zonal, at Hellberget for instance, varying from an almost andesinic kernel (An_{32}) to an albitic shell (An_{11}).

The quartz is always of a distinctly undulous extinction even if, within the central part of the area, some fairly homogeneous quartz may be observed. The primary pyroxene is greenish white, $^{c}/_{\gamma} = 28°$; $2V_{550} = 51.5°$, of a decidedly clinoeustatic-pigeonitic composition, but is mostly replaced by green hornblende.

In the stressed areas, along the dislocation zone N.E. and S.E. of Noppikoski, the amphibole gradually changes into biotite, chlorite, epidote and a colourless mineral recalling zoisite. Closer studies of this lenticularly occurring mineral (cf. Fig. 15) reveal the following optic characteristics:

$(\gamma - \alpha)_{550} = 0.021$ $2V_{550} = +27° 15'$
$n_{\beta, 550} = 1.665$ elongation negative.

The minute quantities occurring in the rock make an isolation and a chemical determination very tedious work and could not be undertaken in this connection, but, calling the mineral X, the following metamorphic succession may be suggested:



This unknown mineral seems to be fairly common in other dynamically metamorphosed rocks too, and has probably by most petrologists been put down as a zoisite. The optic values, however, do not coincide with any normal values of zoisites given in the textbooks, the birefringence being too high and the refraction too low. Neither does it fit in with prehnite.

As previously stated, the normal Rätan granite is of exceptionally uniform character over a large area, this being confirmed by the two analyses Nos. 64—65, executed on samples 30 miles apart, the only variation being practically confined to the range of the plagioclase from An_{16}—An_{23}. Towards the contacts, however, there have developed several different types.

Along the contact towards the greenstones, the granite grades into a more porphyric rock of fine-grained ground-mass. Bright red microcline phenocrysts and some albitic plagioclases (An_4) lie within a granular red base, occasional albite shells being noticeable surrounding the potassic felspar. The albite is centrally sericitised, indicating an originally anortoclasic composition of the kernels (cf. Pl. LX).

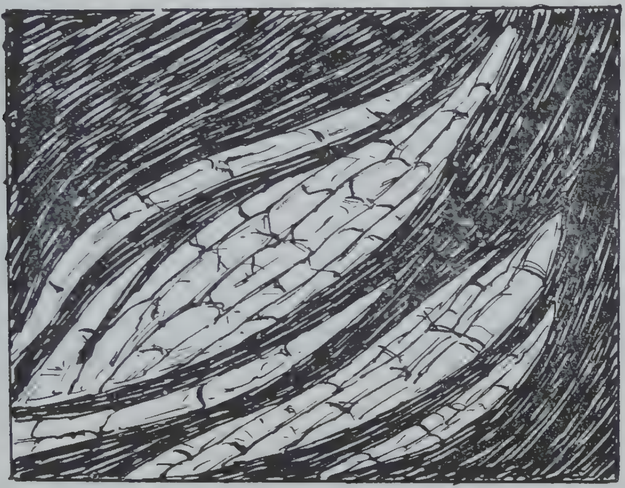


Fig. 15. Zoisitic mineral surrounded by chlorite in Rätan granite. Magnification 60 diam.

Towards the eastern migmatites, the marginal phase is a gray, somewhat porphyric, rock with white potash as well as soda-felspar phenocrysts, the latter of an An_{27} antiperthitic composition. The hornblende occurs in the ground mass as evenly distributed small black prisms, being pseudomorphs of partially preserved augite. The base is poikilitic with circular quartz grains, strongly reminding one of an enlarged copy of the »milky-way» texture of the Dala porphyries described later on in these pages (cf. Pl. LIX).

An analysis of the rock, given in No. 66, indicates the close relationship to the normal type, although the megascopic appearance is strikingly different. Some addition of soda seems to have taken place by absorption of migmatitic material.

Towards the sub-Loosian sediments at Raisberg Hill and Öv. Hamravallen, the granite is coarsly porphyric, almost changing into an »Augen-

Analysis Nr. 64.

Rätan-Granite 3 miles north of Dåasen Lake (Ls - 26).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	64.13	106.35	Q	12.49	Plagioclase		qz	+37	s	71
TiO_2	0.85	1.06	Or	31.19	(Ab_{84} An_{16})	38.5	si	247	A	7.9
P_2O_5	0.42	0.29	Ab	33.53	Microcline	29.8	ti	2.55	C	2.1
Al_2O_3	15.61	15.31	An	9.18	Hornblende	10.4	al	35.5	F	8.8
Fe_2O_3	1.98	1.24	Σ sal	86.39	Quartz	13.4	fm	25.0	a	12.5
FeO	3.18	4.43	Di	2.04	Biotite	3.6	c	12.0	c	3.5
MnO	0.07	0.10	Hy	5.81	Titanite	2.1	alk	27.5	f	14.0
MgO	1.56	3.87	Mt	2.84	Magnetite	1.2	mg	0.36	n	5.3
CaO	2.89	5.15	Ilm	1.64	Apatite	1.0	k	0.47	k	1.12
Na_2O	3.95	6.37	Ap	0.98		100.0	c/fm	0.48		
K_2O	5.30	5.63	Σ fem	13.31						
$H_2O^{+105°}$	0.15	0.83	H_2O	0.15						
				99.86						
	99.74									
$H_2O^{-105°}$	0.05									
	99.79									

Quantitative System: II: 4: 2: 3 — *Adamellose.*

Osann's Type: No. 14. Knudsbakke (s 73, a 11.0, c 4.0, f 15.0, n 4.9, k 1.38).

Or: Ab: An — 42.21: 45.37: 12.42.

Sp. gravity $\frac{16°}{4°}$ C = 2.658.

Analysis Nr. 65.

Rätan-Granite, east of Fågelsjö (Ls - 151).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	63.26	105.33	Q	11.35	Plagioclase		qz	+33	s	71.0
TiO_2	0.72	0·99	Or	30.62	(Ab_{77} An_{23})	43.5	si	241	A	7.8
P_2O_5	0.25	0.18	Ab	33.09	Microcline	27.8	ti	2.06	C	3.1
Al_2O_3	16.69	16.37	An	13.08	Quartz	12.1	al	37.5	F	7.3
Fe_2O_3	1.90	1.19	Σ sal	88.14	Biotite	6.3	fm	22.0	a	13.0
FeO	2.80	3.90	Di	1.14	Hornblende	5.0	c	13.5	c	5.0
MnO	0.06	0.08	Hy	5.34	Magnetite	2.8	alk	27.0	f	12.0
MgO	1.35	3.35	Mt	2.76	Tatanite	1.8	mg	0.35	n	5.3
CaO	3.30	5.88	Ilm	1.37	Apatite	0.7	k	0.47	k	1.12
Na_2O	3.83	6.18	Ap	0.64		100.0	c/fm	0.61		
K_2O	5.19	5.51	Σ fem	11.25						
$H_2O^{+105°}$	0.24	1.33	H_2O	0.24						
				99.63						
$H_2O^{-105°}$	0.12									
	99.71									

Quantitative System: I: 4: 2: 3 — *Toscanose.*

Osann's Type: No. 42. Mt. Johnsson (s 67.5, a 14.0, c 4.0, f 12.0, n 6.8, k 0.97).

Or: Ab: An — 39.87: 43.10: 17.03.

Sp. gravity $\frac{20°}{4°}$ C = 2.652.

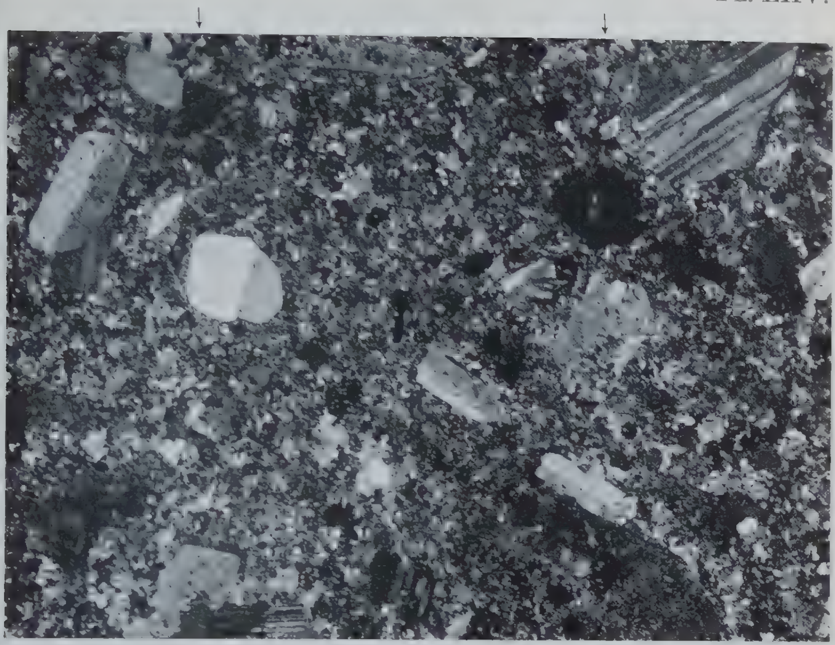


Fig. 1. Quartz-porphyry of the Dala Series from the island between the two canyons at Älvho. The black grains indicated by the arrows are also quartz. Nic. +. Magnif. × 8.

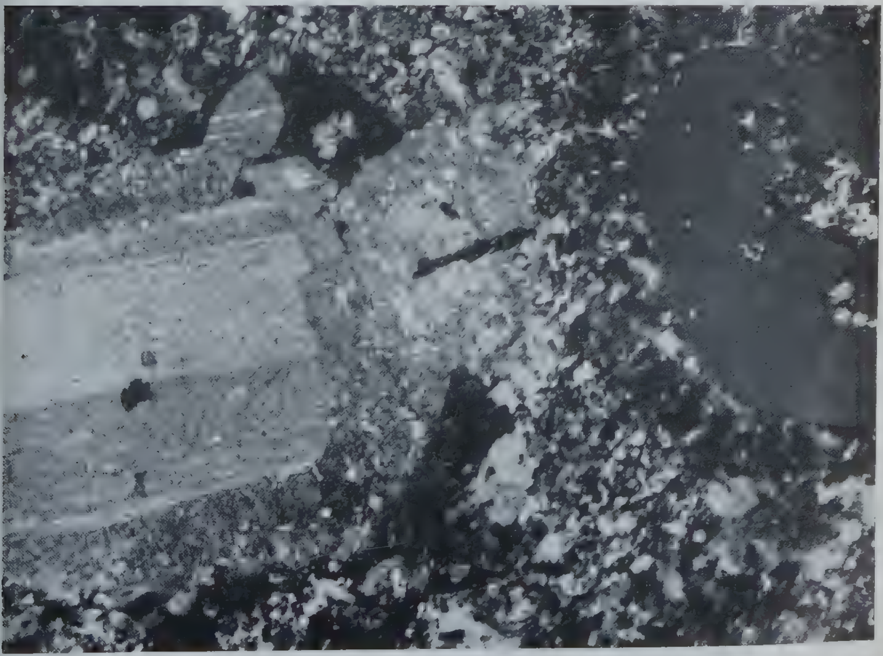
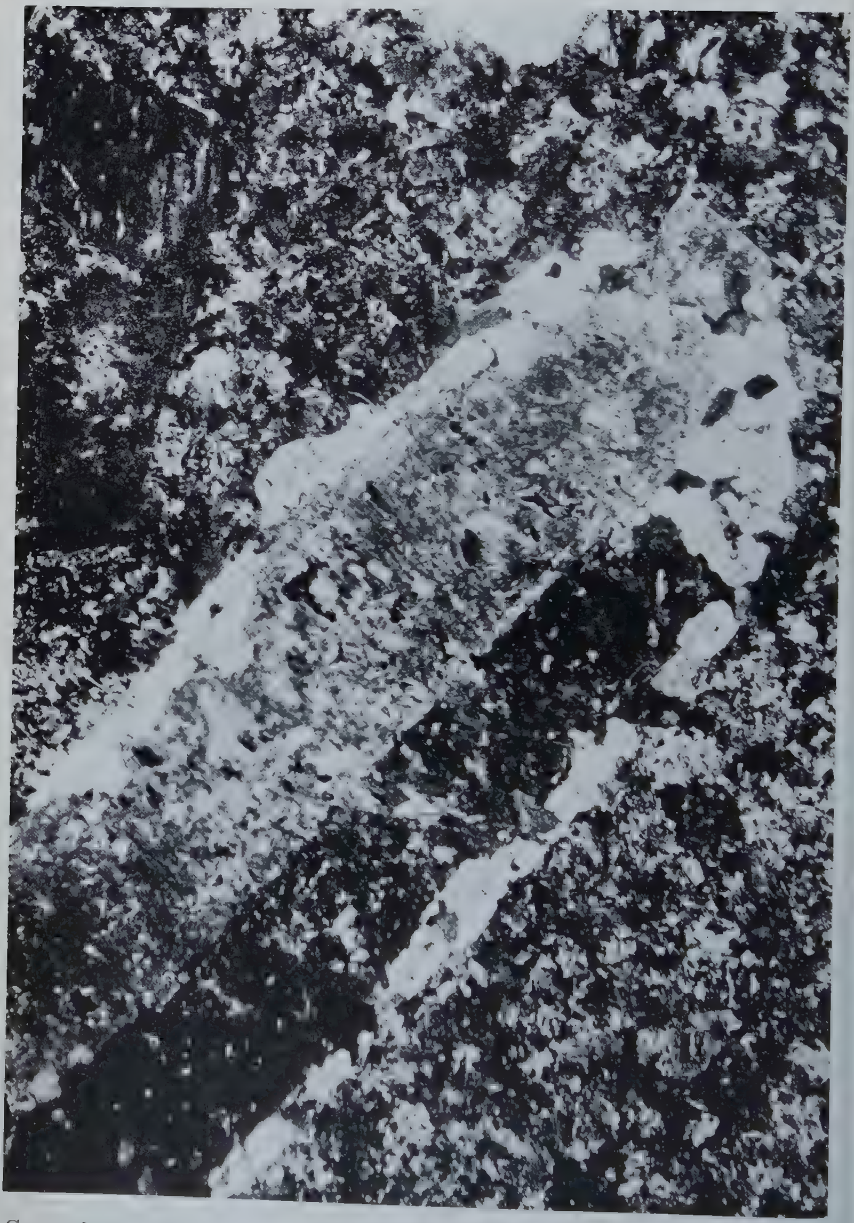


Fig. 2. Quartz-porphyric gronophyre from the island between the two canyons at Älvho. Orthoclase-shell surrounding albitic plagioclase. Corroded quartz phenocryst to the right. Nic. +. Magnif. × 40.



Granophyre from the island between the two canyons at Älvho. Shell of albitic plagioclase surrounding Karlsbader-twin of perthitic orthoclase. Nic. +. Magnif. × 40.

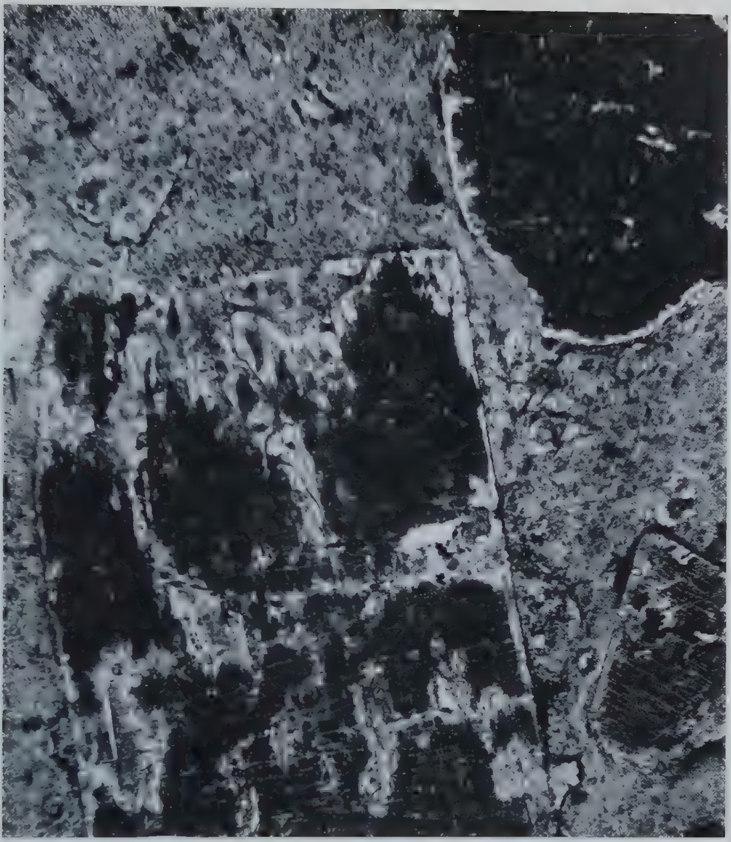


Fig. 1. Porphyry dyke intersecting Noppi slates at Tallsjöbäcken. Patchingly pigmented orthoclase phenocrysts within almost hyaline base. Ord. light. Magnif. × 40.

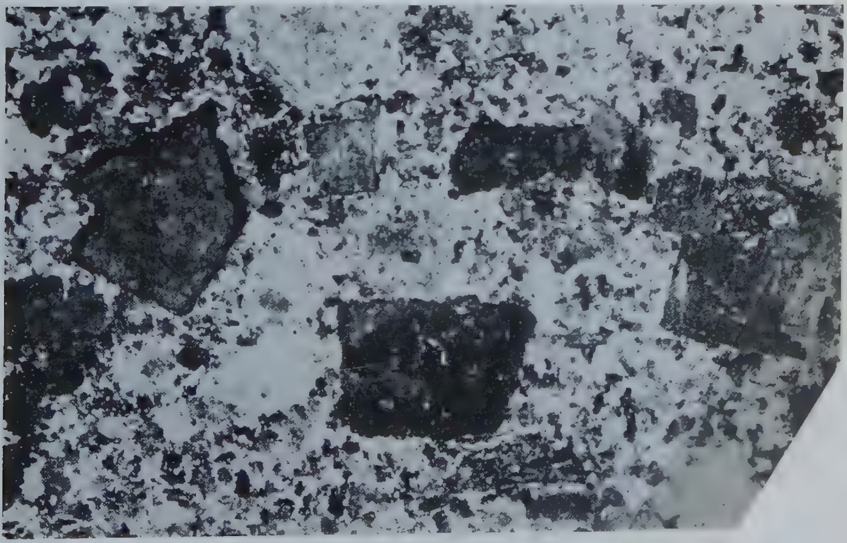
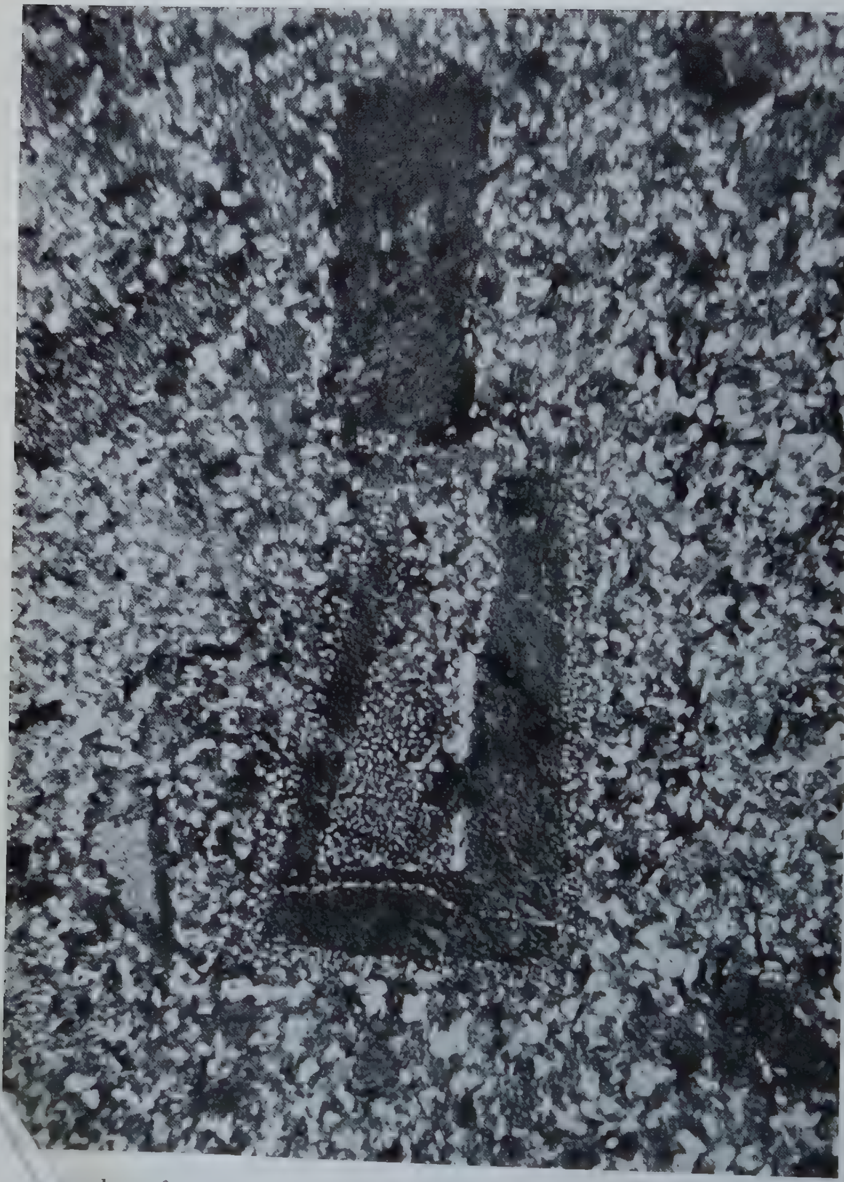


Fig. 2. Coarse porphyry from Harsjömäki W of Knoppen. phenocrysts within micro-granophyric base. Nic. +. Magr



orphyry from Toskåsberget with skeleton of orthoclase crystal. Coarse -way» poikilitic texture due to close proximity to younger doleritic diabase. Ord. light. Magnif. × 40.

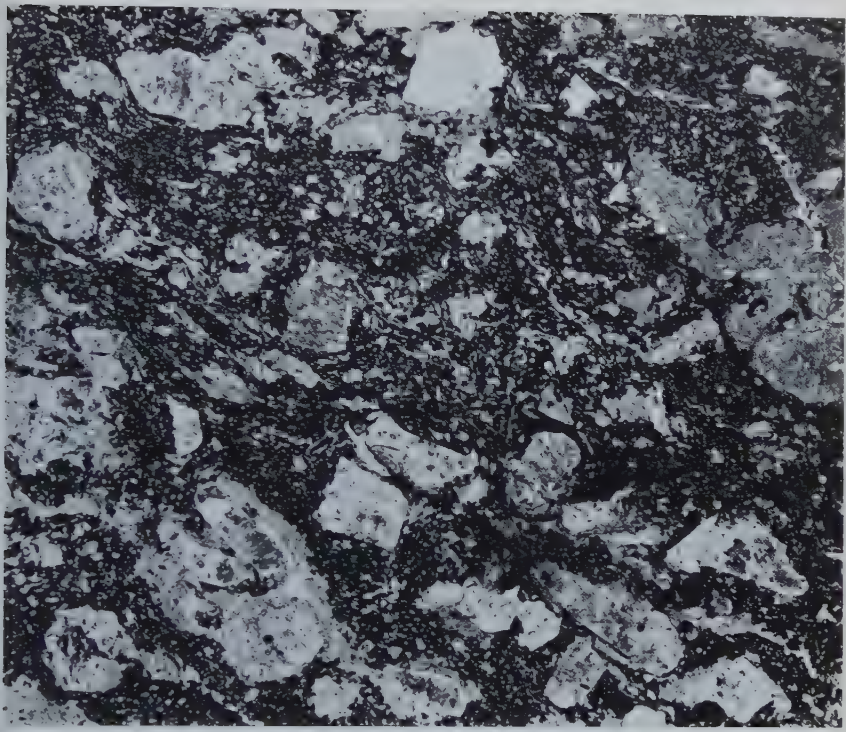


Fig. 1. Strongly Fe-pigmented felsitic effusive porphyry from the northern slope of Pilkalampinoppi. Ord. light. Magnif. × 8.

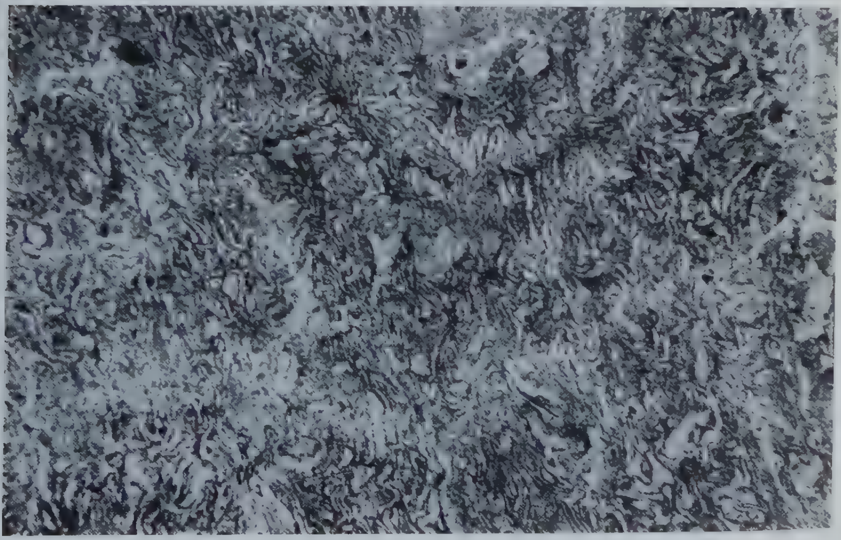
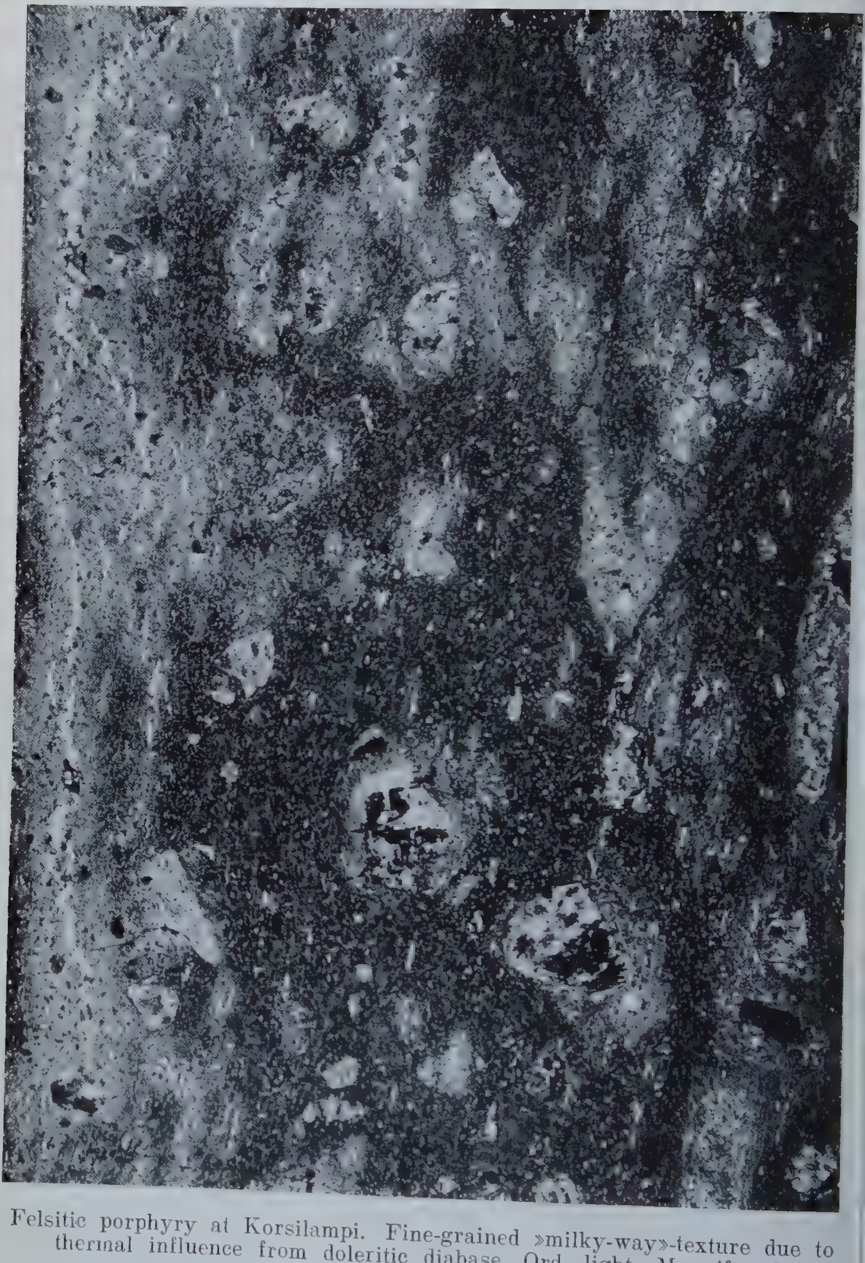


Fig. 2. Felsitic red porphyry SW of Hemgällsjön, SE of Tandsjö. Fluidally foliated groundmass with segregated streaks of quartz. Ord. light. Magnif. × 60.



Felsitic porphyry at Korsilampi. Fine-grained »milky-way»-texture due to thermal influence from doleritic diabase. Ord. light. Magnif. × 8.

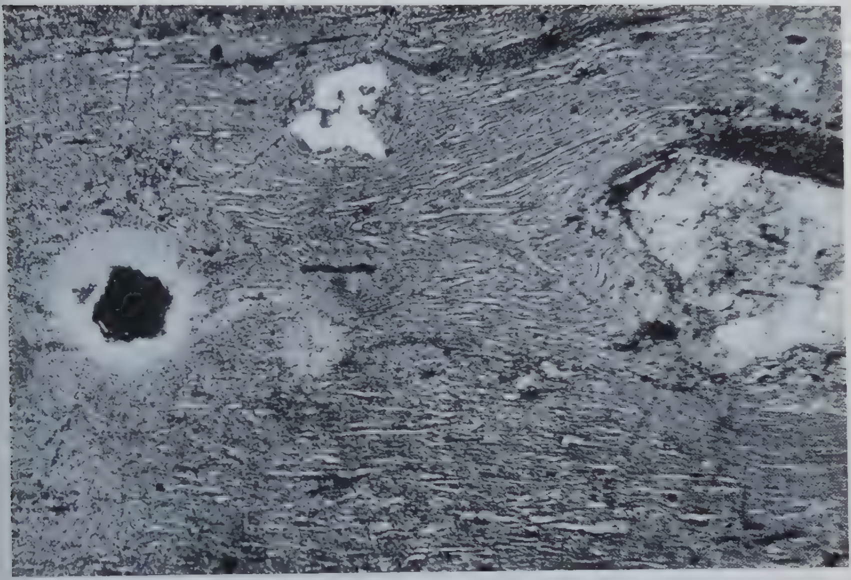


Fig. 1. Felsitic violet porphyry at Flärksjön. Fluidal texture and deoxidized zones around magnetite-grains (to the left). Corroded quartz-grain in the centre; plagioclase-phenocryst to the right. Ord. light. Magnif. × 40.

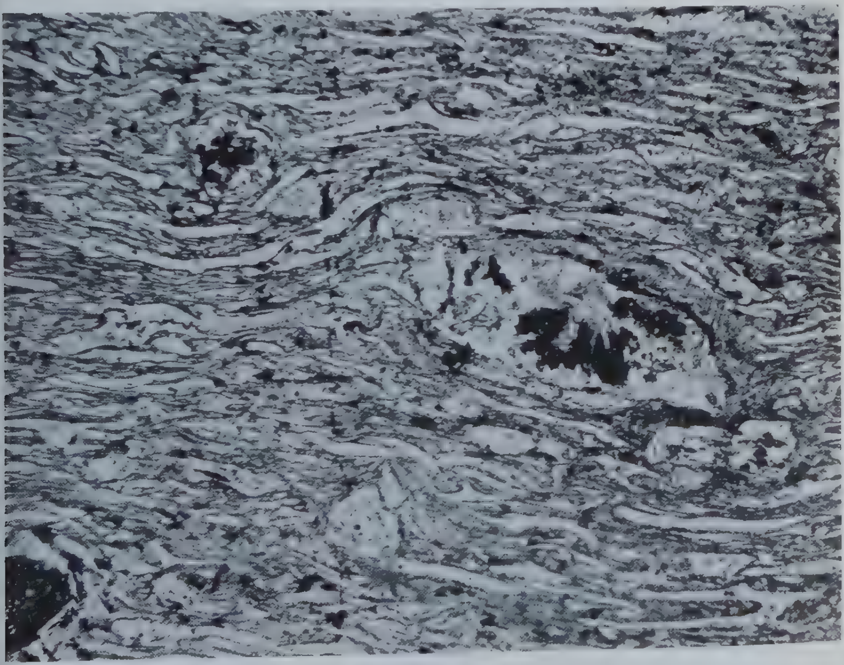
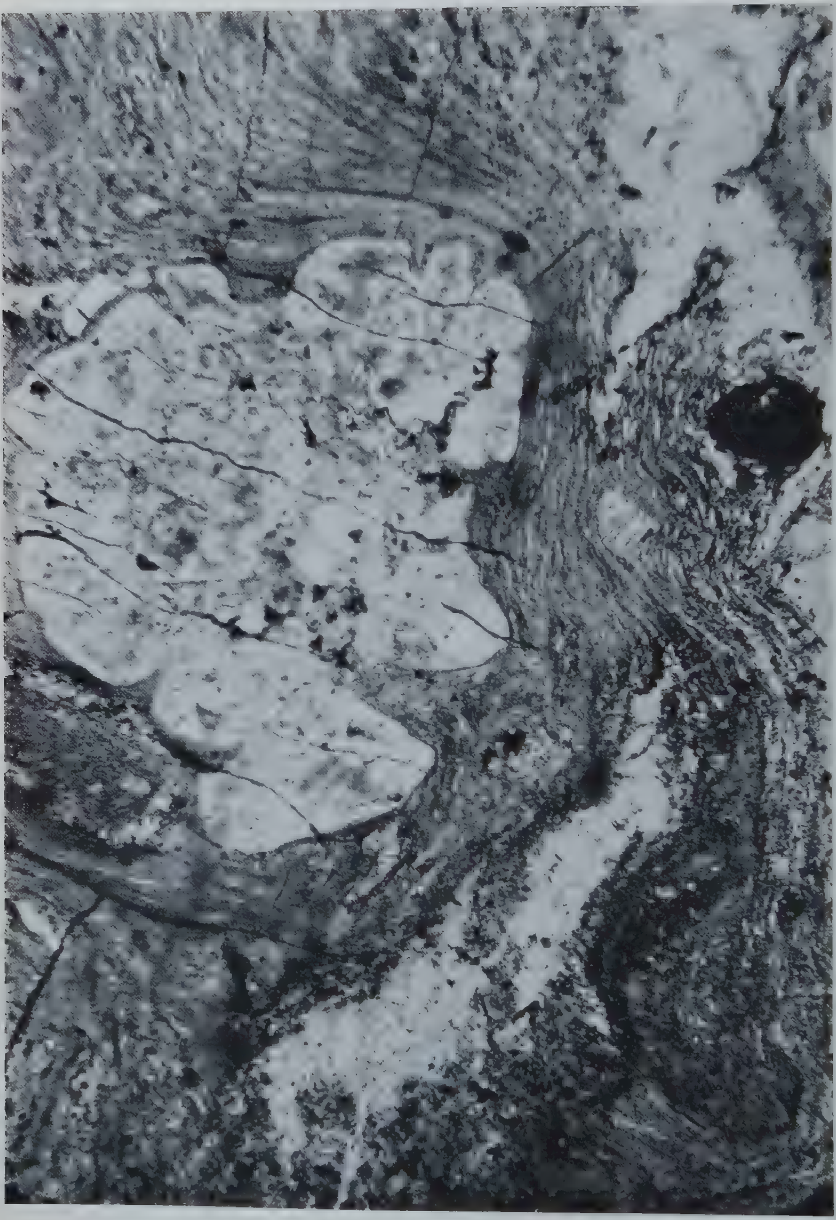


Fig. 2. Felsitic red porphyry S of Gällsjöknoppen. Coarse fluidal texture with streaks of quartz. Ord. light. Magnif. × 40.



Felsitic red porphyry at Gällsjöknoppen. Corroded orthoclase-phenocryst within fluidal micropoikilitic base. Ord. light. Magnif. × 40.

Analysis Nr. 66.

Rätan Granite. Marginal Type north of Loos (Ls - 766).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	67.10	111.72	Q	21.44	Plagioclase		qz	+79	s	74.5
TiO_2	0.75	1.17	Or	27.23	$(Ab_{73}\ An_{27})$	38.1	si	285	A	6.8
P_2O_5	0.16	0.11	Ab	28.33	Microcline	26.3	ti	3.06	C	3.1
Al_2O_3	15.34	15.05	An	13.32	Quartz	22.5	al	38.5	F	5.8
Fe_2O_3	1.35	0.85	Σ sal	90.32	Hornblende		fm	20.5	a	13.0
FeO	2.59	3.61	Di	1.08	(Pseudomorphs		c	14.5	c	6.0
MnO	0.05	0.07	Hy	4.03	of augite)	5.9	alk	26.5	f	11.0
MgO	1.02	2.53	Mt	2.00	Biotite	2.5	mg	0.32	n	5.3
CaO	3.11	5.55	Ilm	1.61	Titanite	2.2	k	0.44	k	1.41
Na_2O	3.37	5.44	Ap	0.34	Magnetite	2.1	c/fm	0.71		
K_2O	4.58	4.86	Σ fem	9.06	Apatite	0.4				
H_2O+105°	0.21	1.17	H_2O	0.21		100.0				
				99.59						
H_2O−105°	0.18									
	99.71									

Quantitative System: I: 4: 2: 3 — *Toscanose.*
Osann's Type: No. 19 Huyserburger Häu (s 76, a 14, c 5.5, f 10.5, n 5.7, k 1.52).
Or: Ab: An — 39.53: 41.13: 19.34.
Sp. gravity $\frac{20°}{4°}$ C: 2.720.

granite» of rounded, almost homogeneous microcline phenocrysts and occasional albitic plagioclases scattered within a granular base of decidedly fluidal texture, emphasized by a yellowish brown biotite.

N. of Sandsjöberg and E. of Lillhamra, the granite assumes a coarsely quartz-porphyric, almost effusive habit characterized by opalizing, optically unhomogeneous quartz grains filled with libellas, much violet fluorite in the base and yellow fluorite within both types of felspar. On the other hand, the quartz of the somewhat poikilitic ground mass is almost homogeneous, and the zonal plagioclase, An_{5-15}, is centrally sericitised. Potash felspars surrounded by incomplete shells of albite grains may be observed occasionally. The orientation of these grains, however, is not parallel to the perthite within the microcline, as Popoff claims in the case with the Rapakivi granites (31). While titanite seems to be wanting, an unusual amount of big and well crystallized zircons is present.

The Rätan granite surrounding the greenstone xenolithe, N.E. of Tandsjö, is worth mentioning. The predominating zonal plagioclase, An_{20-32}, is crystallized in elongated tabular twins within a coarsely micrograniticor granophyric base, rich in microcline. An accession of soda from the greenstone may be presumed.

The most acid and, at the same time, most potassic types of Rätan granites are encountered between Noppikoski and Lillhamra as well as N.E. of Lusbo (Ämån). Their plagioclase is always an acid oligoclase (An_{16-18}), and their mafic constituents are mainly biotite and chlorite. The texture is generally strongly stressed. Very little titanite but much fluorite is present. A chemical account of the rocks is given by analyses Nos. 69—70 (cf. Pl. LXIV, Fig. 1).

Within the great dislocation zone S. of Noppikoski occurs an intermediary type, megascopically crushed almost out of recognition but chemically and mineralogically still retaining some of its primary features. The analysis, No. 71, of this rock agrees nicely with the differentiation diagram of the Rätan granite as given in Fig. 16, some loss of alkalis having resulted from the dynamic metamorphism, but the original oligoclase composition of the felspar still remain.

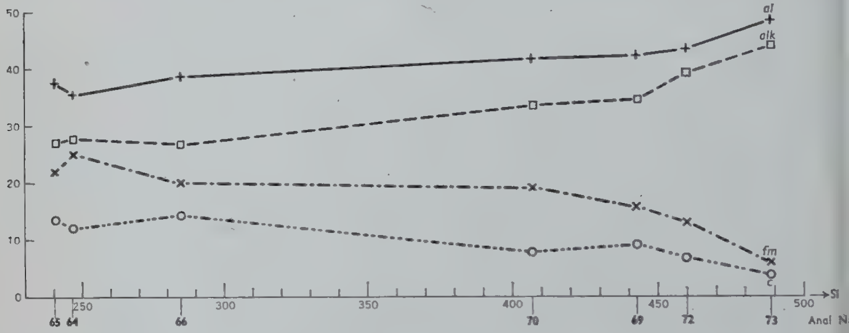


Fig. 16. NIGGLI diagram of Rätan granites.

These acid types all develop nicely granophyric marginal zones towards older rocks. Reference to such an occurence has already been made when discussing the quartz-porphyries at Viidamäki, and the same phenomenon is conspicuous N.E. of Lusbo (cf. Pl. LXI).

All those marginal phases now described are straight-forward cases where the gradual merging into the normal granite may be followed and verified and where the chemical variations may all be explained either as a consequence of a chilling or of a slight contamination at the contact. At the contact towards the slightly gneissose gray variety of the Risberg granite at Svartån S.W. of Rullbo, a more complicated problem is encountered, however. To begin with, it is rather difficult, when travelling along the new road from Rullbo to Svartån, to tell where one granite ends and the other begins. The gneissose granite merges gradually over a distance of some hundred yards into a gray homogeneous granite, chemically elucidated by analyses Nos. 67—68.

Analysis Nr. 67.

Transitory Hybride Rock at the contact of the Rätan-Granite, Svartån (Ls - 686).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	73.31	122.05	Q . .	34.06	Quartz . . .	32.8	qz	+180	s	79
TiO_2	0.20	0.25	Or . .	32.26	Microcline . .	27.9	si	416	A	8.3
P_2O_5	0.19	0.13	Ab . .	22.57	Albite		ti	1.00	C	0.9
Al_2O_2	14.50	14.23	An . .	3.06	(Ab_{93} An_7) .	24.4	al	48.5	F	2.4
Fe_2O_2	0.41	0.26	C . .	3.06	Biotite . . .	7.4	fm	12.5	a	21.5
FeO	1.81	2.52	Σ sal .	95.01	Muscovite . .	5.9	c	5.0	c	2.5
MnO	0.08	0.11	Hy .	3.24	Titanite . . .	0.6	alk	34.0	f	6.0
MgO	0.23	0.57	Mt . .	0.63	Magnetite . .	0.6	mg	0.16	n	4.3
CaO	0.79	1.41	Ilm .	0.40	Apatite . . .	0.4	k	0.57	k	1.46
Na_2O	2.69	4.34	Ap .	0.36		100.0	c/fm	0.38		
K_2O	5.45	5.75	Σ fem	4.63						
$H_2O^{+105°}$	0.36		H_2O .	0.36						
				100.00						
$H_2O^{-105°}$	0.20									
	100.02									

Quantitative System: I: 4: 1: 3 — *Liparose.*
Osann's Type: No. 11. Big Timber Creek (s 80.5, a 20.0, c 3.5, f 6.5, n 4.6, k 1.68).

Or: Ab: An — 55.73: 38.98: 5.29.

Sp. gravity $\frac{20°}{4°}$ C: 2.650.

Analysis Nr. 68.

Transitory Hybrid Rock between the Rullbo and Rätan-Granite (Ls - s - 103) Svartå Brook.

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	74.17	123.49	Q . . .	37.72	Quartz . . .	38.0	qz	+208	s	80.5
TiO_2	0.15	0.19	Or . . .	30.61	Microcline . . .	27.0	si	442	A	7.0
P_2O_5	0.35	0.25	Ab . .	20.47	Plagioclase		ti	0.72	C	1.5
Al_2O_3	13.28	13.03	An . .	3.61	(Ab_{88} An_{12})	23.5	al	46.5	F	2.3
Fe_2O_3	0.65	0.41	C . . .	2.34	Biotite, Musco-		fm	12.0	a	19.5
FeO	1.54	2.14	Σ sal .	94.70	vite	10.1	c	8.0	c	4.0
MnO	0.04	0.06	Hy . .	2.40	Apatite . . .	1.0	alk	33.5	f	6.5
MgO	0.16	0.40	Ap . .	0.91	Titanite . . .	0.4	mg	0.12	n	4.1
CaO	1.26	2.25	Mt . .	0.94		100.0	k	0.59	k	1.70
Na_2O	2.43	3.92	Ilm . .	0.29			c/fm	0.68		
K_2O	5.18	5.50	Σ fem .	4.54						
$H_2O^{+105°}$	0.54	3.00								
			H_2O .	99.83						
	99.75									
$H_2O^{-105°}$	0.20									

Quantitative System: I: 3: 1: 3 — *Alascose.*
Osann's Type: No. 11. Big Timber Creek (s 80.5, a 20, c 3.5, f 6.5, n 4.9, k 1.68).

Or: Ab: An — 55.97: 35.43: 6.60.

Sp. gravity $\frac{20°}{4°}$ C: 2.634.

Analysis Nr. 69.

Red acid Rätan Granite of Point 497.1 by road from Hamra to Noppikoski (Ls - 602).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	73.92	123.08	Q . . .	36.28	Quartz . . .	33.1	qz	+ 207.5	s	81.5
TiO_2	0.31	0.49	Or . .	30.05	Microcline . .	29.3	si	443.5	A	6.4
P_2O_5	0.08	0.06	Ab . .	22.02	Plagioclase		ti	1.80	C	1.2
Al_2O_2	11.82	11.60	An . .	5.56	(Ab_{82} An_{18})	27.2	al	41.5	F	3.4
Fe_2O_2	1.52	0.95	Σ sal .	93.91	Chlorite . . .	7.3	fm	15.5	a	17.5
FeO	1.22	1.70	Di . .	0.46	Ores	2.9	c	9.0	c	3.5
MnO	0.03	0.04	Hy . .	0.75	Apatite . . .	0.2	alk	34.0	f	9.0
MgO	0.27	0.67	Mt . .	2.24			mg	0.17	n	4.4
CaO	1.40	2.50	Ilm . .	0.67		100.0	k	0.56	k	1.84
Na_2O	2.60	4.19	Ap . .	0.24			c/fm	0.58		
K_2O	5.09	5.40	Σ fem .	4.36						
$H_2O^{+105°}$	1.36	7.55	H_2O .	1.36						
				99.63						
$H_2O^{-105°}$	0.15									
	99.77									

Quantitative System: I: 3: 2: 3 — *Tehamose.*
Osann's Type: No. 12. Alby (s 79, a 17.5, c 3.5, f 9, n 4.4, k 1.62).
Or: Ab: An — 52.14: 39.21: 9.65.
Sp. gravity $\frac{20°}{4°}$ C: 2.659.

Analysis Nr. 70.

Red acid Rätan Granite at main road N. W. of Råberg, north of Noppikoski (Ls - 779).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	73.44	122.28	Q . .	33.21	Quartz . . .	32.5	qz	+ 175.5	s	80.5
TiO_2	0.27	0.42	Or . .	29.47	Plagioclase		si	407.5	A	6.5
P_2O_5	tr.	—	Ab . .	24.13	(Ab_{83} An_{17})	29.3	ti	1.33	C	1.5
Al_2O_3	12.50	12.26	An . .	6.09	Microcline . .	27.9	al	41.0	F	3.6
Fe_2O_3	1.12	0.70	C . . .	0.20	Biotite, horn-		fm	19.0	a	17.0
FeO	2.22	3.09	Σ sal .	93.10	blende and		c	7.0	c	3.5
MnO	0.05	0.07	Hy . .	3.86	chlorite . .	8.1	alk	33.0	f	9.5
MgO	0.43	1.07	Mt . .	1.61	Ores	2.2	mg	0.19	n	4.6
CaO	1.21	2.16	Ilm . .	0.55		100.0	k	0.54	k	1.75
Na_2O	2.86	4.61	Σ fem .	6.02			c/fm	0.40		
K_2O	4.97	5.28	H_2O .	0.68						
$H_2O^{+105°}$	0.68	3.78		99.80						
$H_2O^{-105°}$	0.15									
	99.90									

Quantitative System: I: 4: 2: 3 — *Toscanose.*
Osann's Type: No. 12. Alby (s 79, a 17.5, c 3.5, f 9, n 4.4, k 1.62).
Or: Ab: An — 49.39: 40.43: 10.18.
Sp. gravity $\frac{20°}{4°}$ C : 2.622.

Analysis Nr. 71.

Rätan Granite at Tenningån north of Öberget Hill, east of Emådalen Station (Ls - s - 10).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	71.66	119.31	Q . . 33.46	Microcline . . 42.5	qz +171	s 79.0
TiO_2	0.39	0.49	Or . . 41.17	Plagioclase	si 387	A 6.6
P_2O_5	0.06	0.04	Ab . . 8.37	(Ab_{75} An_{25}) 11.5	ti 1.62	C 1.9
Al_2O_3	13.05	12.80	An . . 6.94	Quartz . . . 30.0	al 41.5	F 4.1
Fe_2O_3	0.65	0.41	C . . . 1.32	Hornblende . 13.8	fm 20.5	a 15.5
FeO	3.31	4.61	Σ sal . 91.26	Ores 1.0	c 9.0	c 4.5
MnO	0.08	0.11	Hy . . 5.82	Titanite . . . 1.0	alk 29.0	f 10.0
MgO	0.32	0.79	Ap . . 0.23	Apatite . . . 0.2	mg 0.13	n 1.8
CaO	1.56	2.78	Mt . . 0.94	100.0	k 0.82	k 1.66
Na_2O	0.97	1.57	Ilm . . 0.75		c/fm 0.44	
K_2O	6.96	7.39	Σ fem . 7.74			
H_2O + 105°	0.75	4.16	H_2O . 0.75			
			99.75			
H_2O − 105°	0.10					
	99.86					

Quantitative System: I: 4: 2: 2 — *Dellenose.*
Osann's Type: No corresponding Type.
Or: Ab: An — 75.02: 14.82: 10.16.
Sp. gravity $\frac{16^\circ}{4^\circ}$ C = 2.644.

Analysis Nr. 72.

Acid red Rätan Granite from Myggsjö.

Analysts: H. von Eckermann and G. Haglund.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	74.39	123.86	Q . . 35.02	Microcline . 41.1	qz +206	s 82.0
TiO_2	0.20	0.25	Or . . 38.37	Quartz . . . 36.6	si 460	A 6.9
P_2O_5	0.05	0.04	Ab . . 18.37	Plagioclase	ti 0.93	C 0.6
Al_2O_3	11.66	11.44	An . . 2.79	(Ab_{90} An_{10}) 19.0	al 42.5	F 3.0
Fe_2O_3	1.52	0.95	Σ sal . 94.55	Chlorite, horn-	fm 12.5	a 20.0
FeO	0.68	0.95	Di . . 1.34	blende, augite 1.9	c 6.5	c 1.5
MnO	0.03	0.04	Mt . . 1.54	Ores 1.1	alk 38.5	f 8.5
MgO	0.20	0.50	Ilm . . 0.40	Pigmentation 0.3	mg 0.17	n 3.4
CaO	0.98	1.75	Hm . . 0.46	100.0	k 0.66	k 1.80
Na_2O	2.19	3.53	Σ fem . 3.74		c/fm 0.52	
K_2O	6.47	6.87	H_2O . 1.42			
H_2O + 105°	1.42	7.88	99.71			
H_2O − 105°	0.17					
	99.96					

Quantitative System: I: 4: 2: 2 — *Dellenose.*
Osann's Type: No. 5. Elk Peak (s 81, a 20.5, c 2, f 7.5, n 5.0, k 1.69).
Or: Ab: An — 64.46: 30.86: 4.68.
Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.642.

Actually, these analyses are almost identical with analysis No. 45 (cf. p. 222) already given of the gray Rullbo granite, the main difference being a somewhat lower percentage of muscovite in the mode (cf. Pl. LXII, Fig. 1).

There is a temptation to explain the gray Rullbo granite as being throughout a gneissose marginal phase of the Rätan granite, but fragments of the gneissose gray granite, observed at Svartån brook included with the homogeneous gray granite, exclude this possibility. Microscopically, the megascopically homogeneous granite is strongly protoclastic, exhibiting bent felspars and strongly undulous extinction of the quartz. It may, consequently, be considered as either a thermally metamorphosed Rullbo granite or as a highly contaminated Rätan granite. In both cases, the hybrid rock was generated both by the re-fusion, under strong hydrostatic pressure, of the Rullbo granite as well as by an intimate exchange of material between the two granites. Towards the N.W., it gradually merges into the true Rätan granite, no magmatic joint being observable in the well-exposed outcrops.

The remelting power of the Rätan granite is in this case rather strange, considering the slight influence of the same granite at all other observed contacts. No unusual concentration of volatiles or generation of pegmatites at the Svartåbäcken contact has been observed. A possible explanation of this unusual behaviour may be given, however, if attention be paid to an earlier theory advanced by the present author when discussing the granites along the Baltic coast of southern Norrland. He showed the probability of a maximum degree of anatexis being attained when the regenerated or contaminated magma fitted into the natural differentiation scheme of the intruding magma. In order to test his suggestion, two analyses Nos. 69 and 70, were executed on samples of the hybrid rock. Even if these analyses do not show complete agreement with the NIGGLI diagram of the Rätan granites as given in Fig. 15, they approach it fairly closely, however.

Finally, a few words may be said respecting the aplitic dykes cutting the granite and constituting its most acid differentiates. The E. slope of Tvättkölen ridge N.E. of Rullbo, for instance, is brecciated by such dykes, which were already observed by SVEDMARK and assumed by him to be associated with the Sandsjö Rapakivi, this latter granite, consequently, being mapped by him as a younger rock. His conclusions in this respect have been verified by the present survey, although they have been shown to be based on wrong premises. The mode of the appended analysis, No. 73, and the texture of the rock itself clearly indicate consanguinity with the Rätan granite. All the potash felspar occurs as microcline and the quartz displays more or less optic strain,

Analysis Nr. 73.

Aplite cutting Rätan Granite south of Bäcknästjärn, north of Tandsjö.
(Ls - 508).
Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	76.92	128.07	Q	35.02	Albite (Ab_{94} An_6)	36.4	qz	+215	s	83
TiO_2	0.04	0.05	Or	26.70			si	489	A	7.7
P_2O_5	0.00	—	Ab	34.08	Quartz	35.1	ti	0.0	C	0.3
Al_2O_3	12.58	12.34	An	2.47	Microcline	26.6	al	47.5	F	1.1
Fe_2O_3	0.82	0.51	C	0.10	Chlorite, Biotite	1.1	fm	5.5	a	25.0
FeO	0.21	0.29	Σ sal	98.37			c	3.5	c	1.5
MnO	tr.	—	Hy	0.19	Magnetite	0.7	alk	43.5	f	3.5
MgO	0.07	0.17	Mt	0.47	Titanite	0.1	mg	0.14	n	5.5
CaO	0.48	0.86	Hm	0.49		100.0	k	0.44	k	1.73
Na_2O	4.02	6.48	Ilm	0.11			f/cm	0.60		
K_2O	4.51	4.79	Σ fem	1.26						
H_2O + 105°	0.12	0.67	H_2O	0.12						
				99.75						
H_2O − 105°	0.21									
	99.98									

Quantitative System: I: 4: 1: 3 — *Liparose*.
Osann's Type: No. 4 Milford (s 82.5, a 24, c 2, f 4, n 5.4, k 1.74).
Or: Ab: An — 42.21: 53.82: 3.97.
Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.608.

the texture generally being somewhat quartz-porphyric and granophyric. The plagioclase is a basic albite (An_{5-6}), and the mafic minerals are limited to some biotite and muscovite. The aplitic dykes, consequently, do not, as previously assumed, belong to the dynamically totally unaffected Sandsjö granite (cf. Pl. LXII, Fig. 2, LXIII).

Returning to the question of the age of the Rätan granite, the author ventures to consider the concurring data dealt with above as firmly establishing the pre-Rapakivi age of the Rätan granite. The intrusion of this granite must have preceded the extrusion of the earlier Jotnian Dala porphyries by a very large margin of time, this being shown, not only by the removal of large blocks of Noppi-sediments, folded at the time of the intrusion, but also by the erosion, having reached the intrusion level of the granite. Dynamically, the continued orogenesis has affected the granite itself, even within the deepest and most sheltered part of its large nothern area, before the beginning of the Jotnian epoch. The connection between the aplitic dykes of the granite and the pre-Jotnian Noppi porphyries is also clearly evident; texturally, some of the aplites are strikingly porphyric, and their granophyric base is an enlarged copy of the micro-poikilitic ground mass of the porphyries. Chemically, the consanguinity is perfect.

On the other hand, a megascopical as well as chemical likeness between the Rätan and the Jotnian Rapakivi granites is unquestionable, making the earlier correlation of the two quite understandable. Even if the field evidences and the difference in dynamic metamorphism have definitely ruled out such a correlation, the author nevertheless ventures to suggest a very deep-seated magmatic connection between the two rocks, notwithstanding the long epoch separating their respective intrusions at higher levels of the earth crust and the extrusion of their lavas.

Both granites are characterized by their lack of accompanying pegmatites. Both are conspicuous by their titanium and fluorine content. Both develop in their acid differentiates plagioclase shells around orthoclase-phenocrysts, and granophyric or poikilitic textures. They do not follow strictly the same line of differentiation, but the trend of their NIGGLI-diagrams is the same.

Their occurence within the same geographical regions is certainly not a coincidence but suggests some kind of magmatic relationship, even if it be one many times removed.

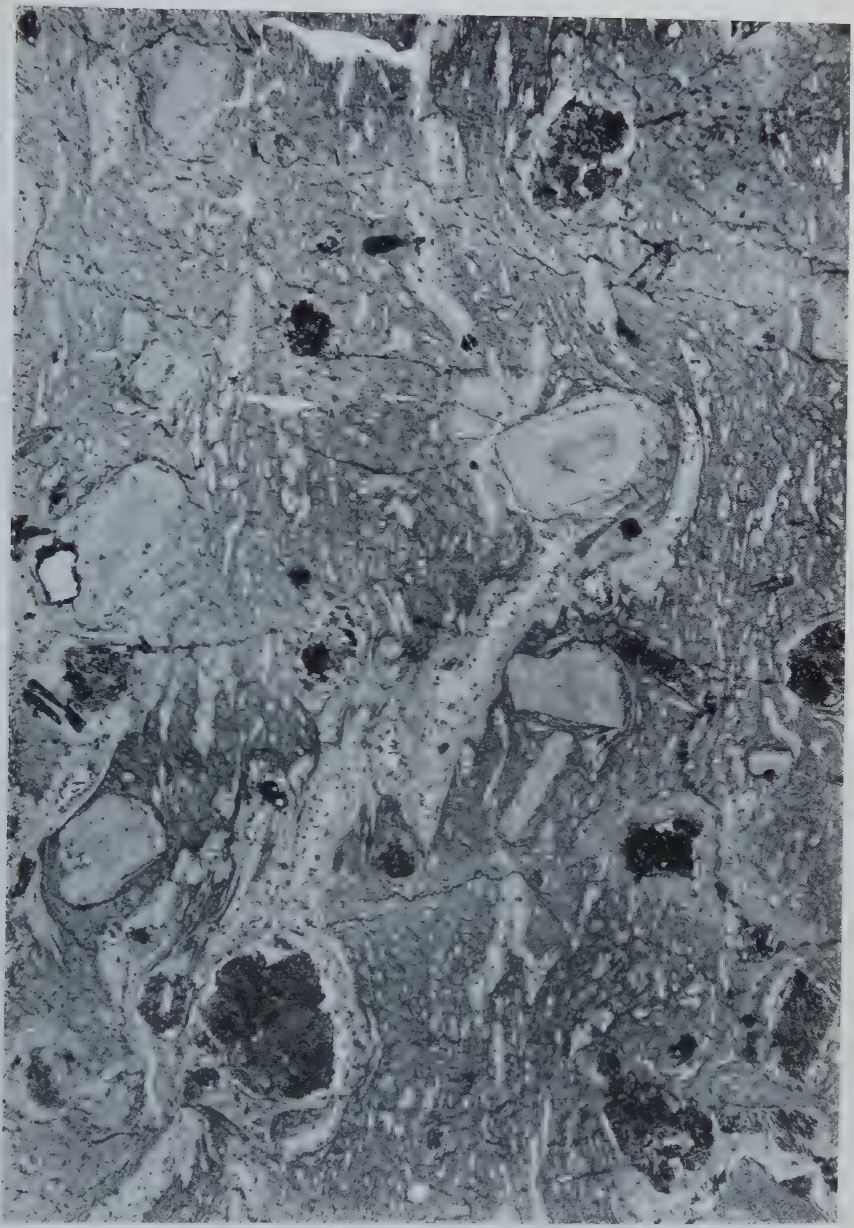
The writer's suggestion really involves a theory that this magmatic province was maintained through long epochs separated by at least one extensive epoch of mountain folding and erosion

The Dala Series.

The Basal Conglomerate.

The unconformity on top of the Noppi-series is very evident, thanks to the coarse conglomerate dipping westwards below the Dala porphyries along the road from Noppikoski to Älvho. The same conglomerate is found topping the graywackes at Gäddsjöberget, S. of Älvho, and also the slates and quartzites, occurring respectively S.E. of Lekattkölen and N.W. and W. of Gråtbäck station. It also occurs at Tallsjöbäcken (cf. Pl. LVI, Fig. 1) and is left as a narrow strip along the W. dislocation zone of the raised area S. of Älvho. It also underbeds the Dala series at Lustjärnsberget and occupies most of Middagsberget (cf. Pl. LVII). The pebbles are sometimes as big as boulders, but generally they average 5—10 cm. in diameter. On inspecting 400 pebbles of the conglomerate N.E. of Noppikoski, the following percentages of various rocks were found:

60 %	quartzite (top of Noppi-series).
18 %	quartz-porphyry and tuffs.
16 %	older quartzites.
6 %	old granite and gneiss granites.



Felsitic reddish-black porphyry. Fluidal texture with segregations of quartz. Dark-red orthoclase- and light-gray plagioclase phenocrysts. Ord. light. Magnif. × 8.

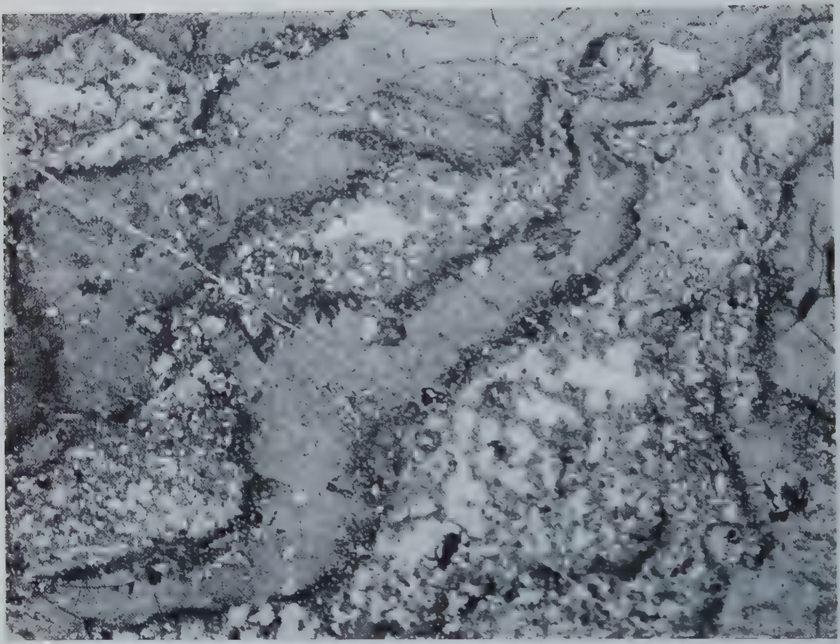


Fig. 1. Fluxion-texture within felsitic porphyry-pebble from the conglomerate at Bössfallet. Ord. light. Magnif. × 8.

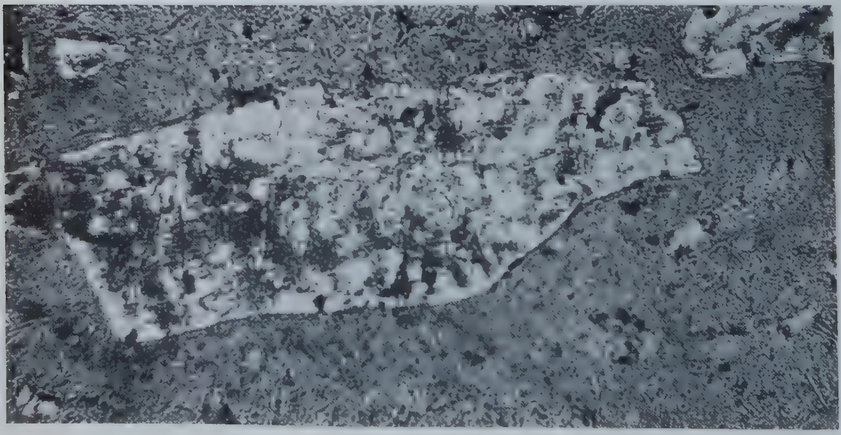
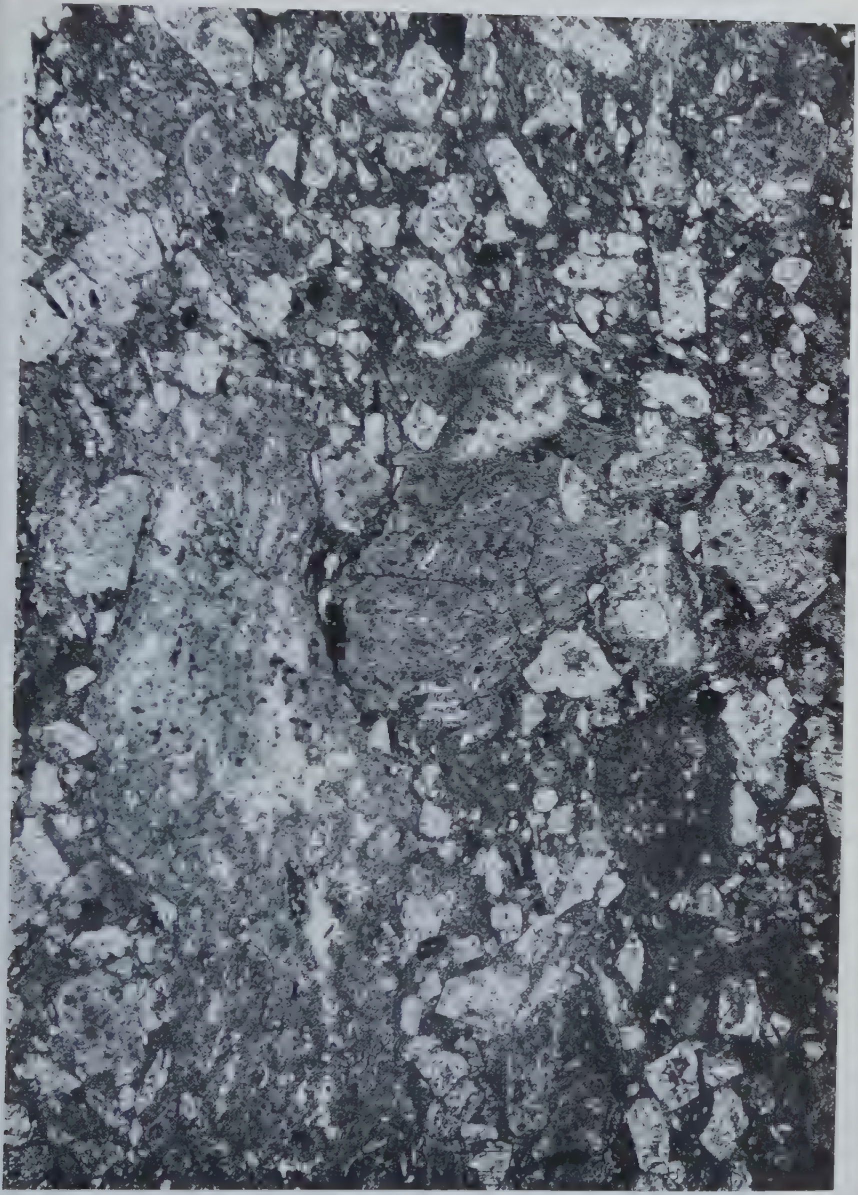
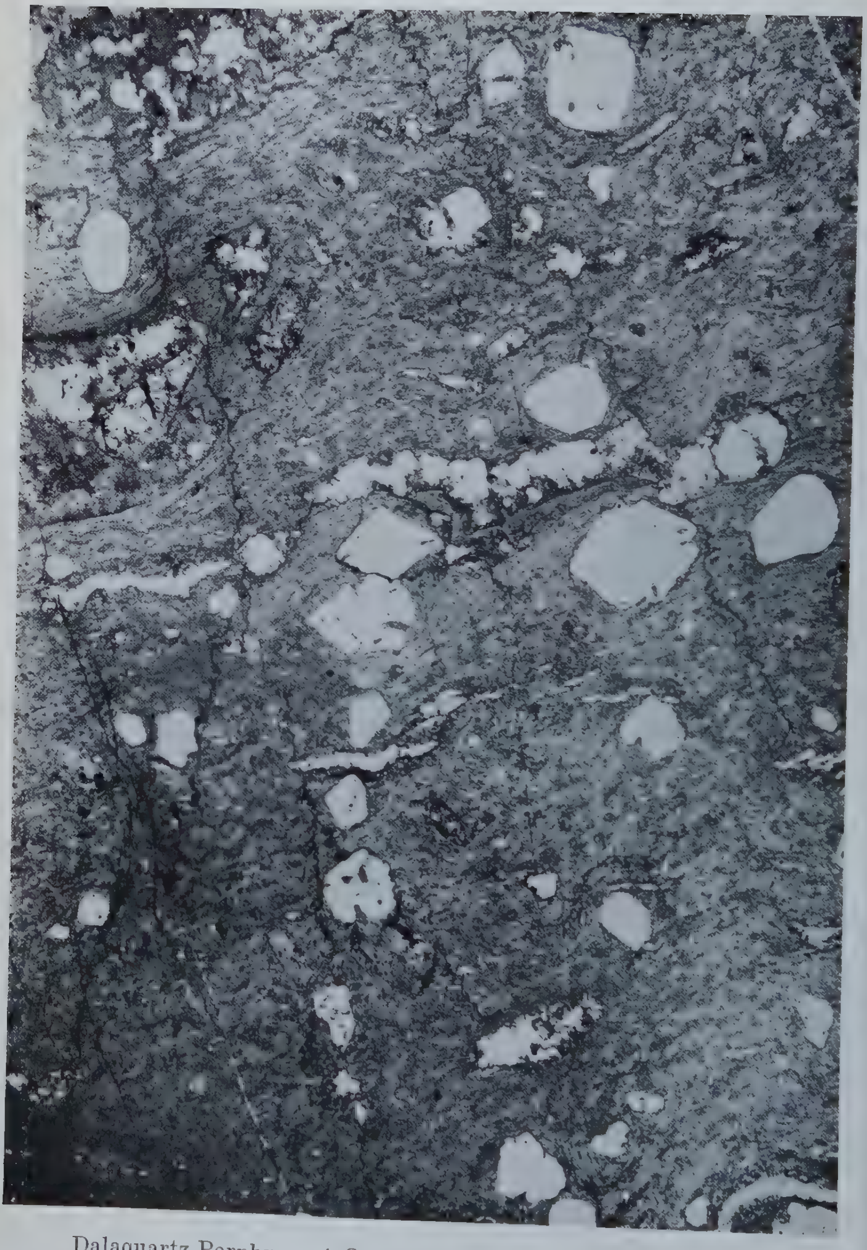


Fig. 2. Brownish-black porphyry with corroded orthoclase crystal. Small streaks of quartz-grains in the base. Ord. light. Magnif. × 40.



Porphyry W of Tallsjöbacken. Orthoclase crystals within fluidal groundmass. Ord. light. Magnif. × 8.



Dalaquartz-Porphyry at Ormvasslan. Ord. light. Magnif. × 10.

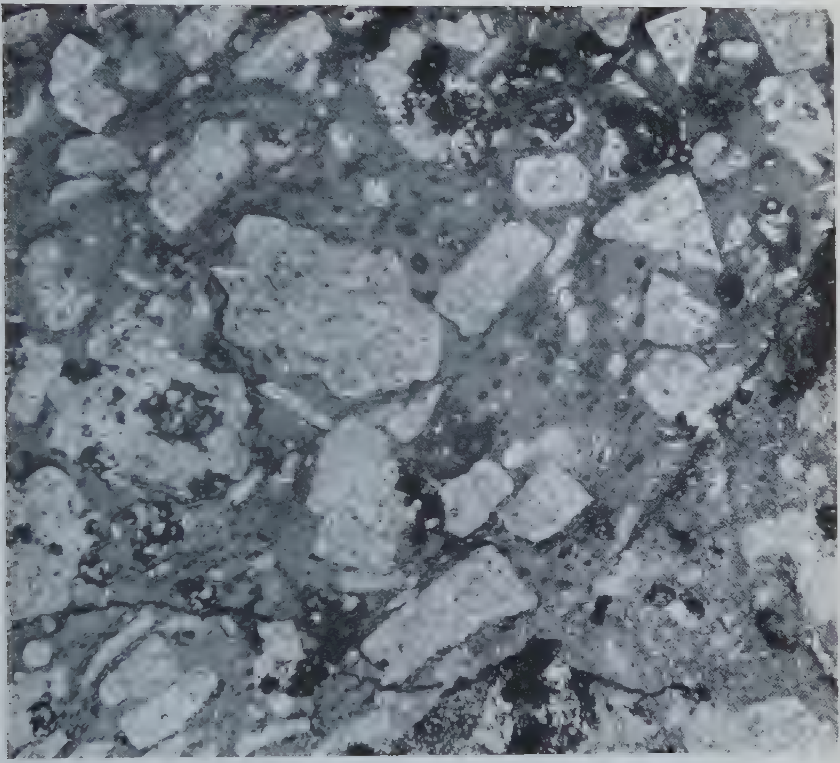


Fig. 1. Green porphyrite at Tandsjö. Ord. light. Magnif. × 8.

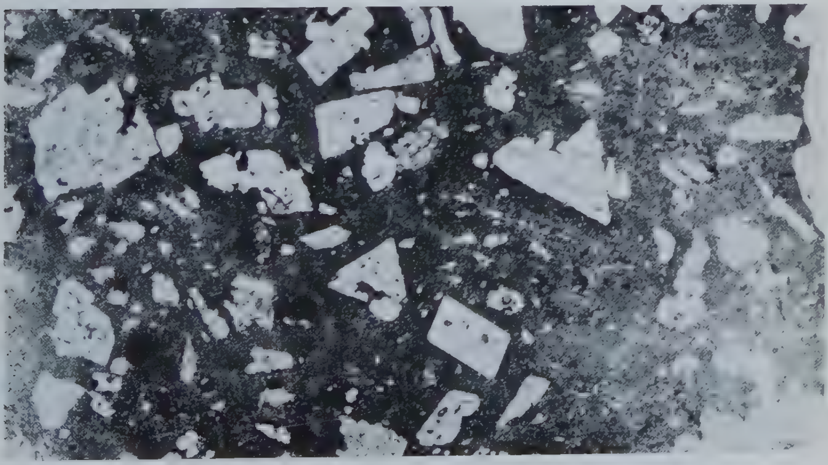


Fig. 2. Red felsitic porphyrite from Granvasslan. Ord. light. Magnif. × 8.

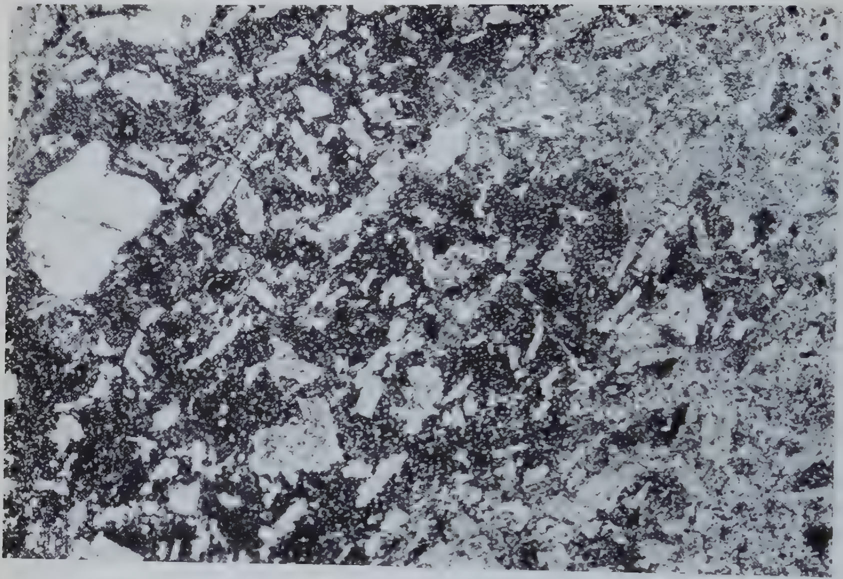


Fig. 1. Effusive violet diabasic porphyrite from Korrisberget. To the left a vesicle filled with calcite and quartz. To the right (light gray) manganese-epidote. Ord. light. Magnif. × 8.

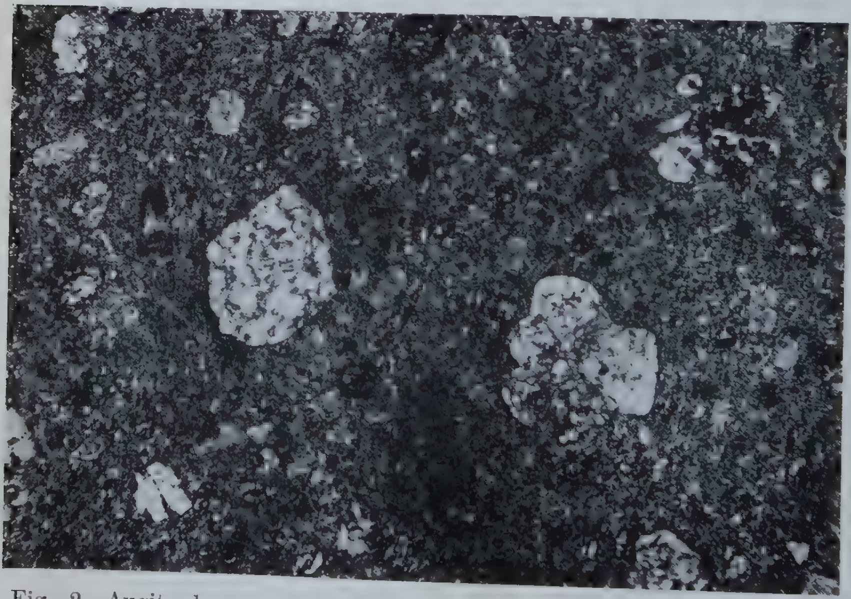


Fig. 2. Augite-phenocrysts within micropoikilitic base. Dark-green porphyrite dyke at Sundsjöån. Ord. light. Magnif. × 40.

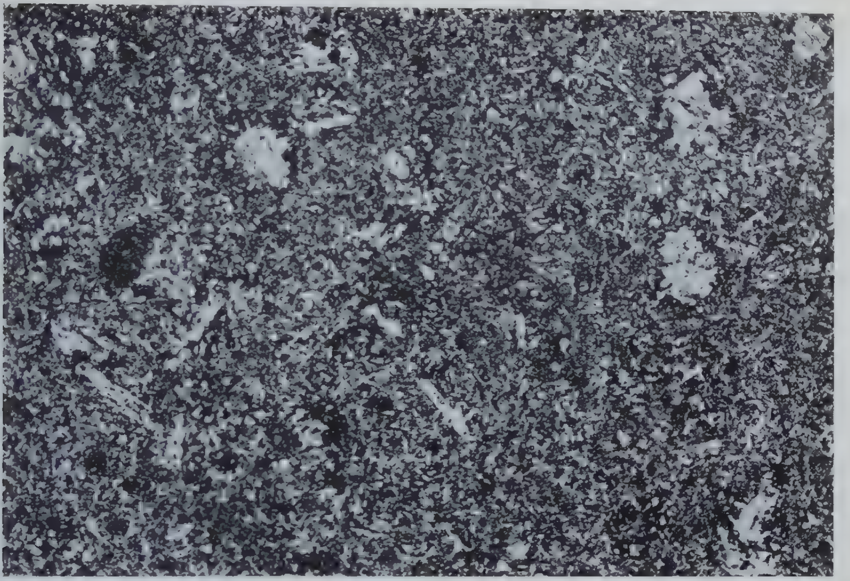


Fig. 1. Diabasic porphyrite from Uttertjärnberget. Ord. light. Magnif. × 8.

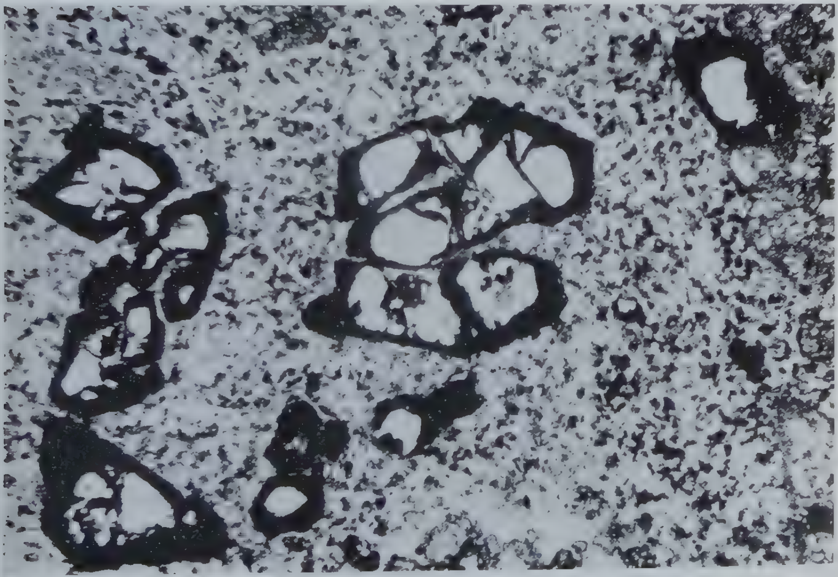
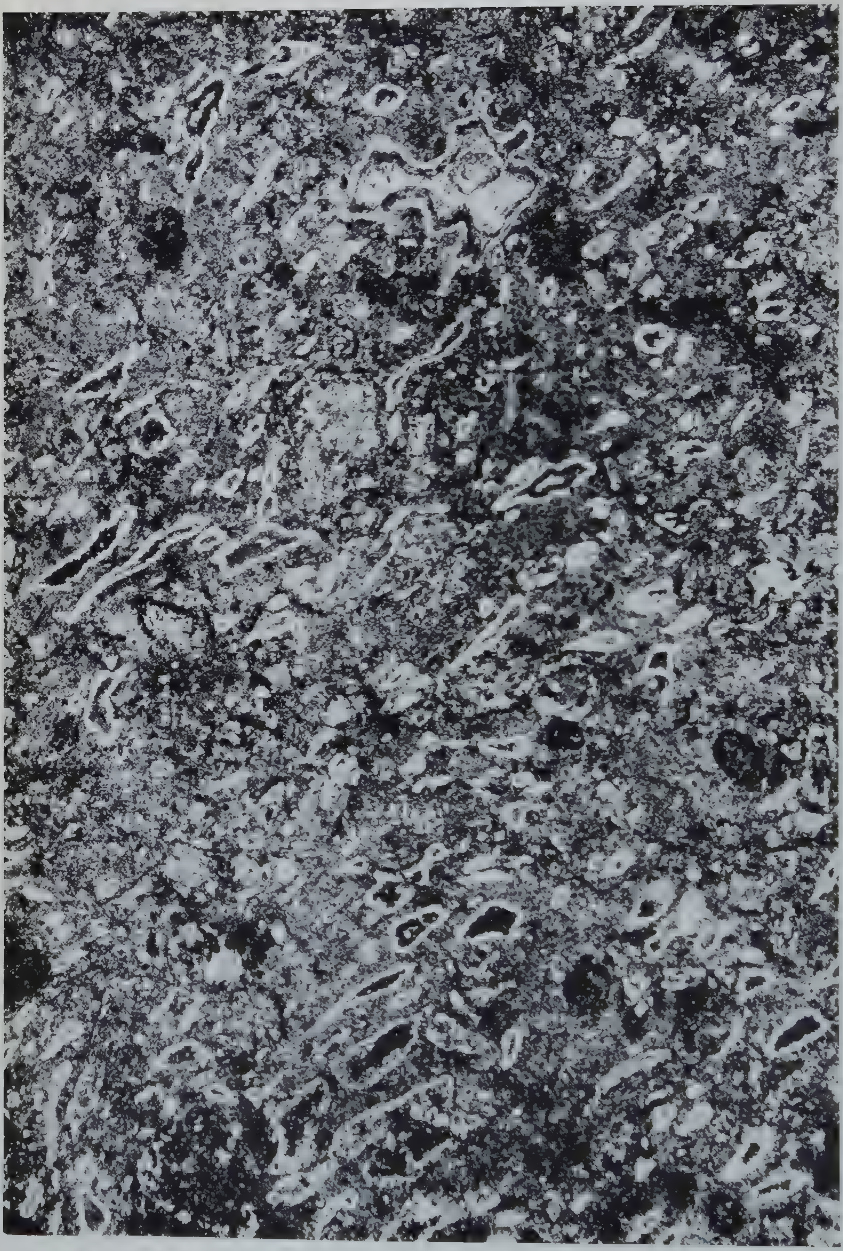


Fig. 2. Olivine-pseudomorphs within green porphyrite from Korrisberget. Black spots are ores. Ord. light. Magnif. × 40.



Effusive porphyrite NW of Emådalen, thermally metamorphosed by monzonite (cfr. Pl. LXXXI). Ord. light. Magnif. × 8.

The immediately underlying quartzite is very easy to recognize among the pebbles, thanks not only to its clastic texture but also to the characteristic presence of pyrite. Up to 50 % of the quartz-porphyry is of effusive types. Ryolitic, almost vitrous rocks filled with ash-fragments as well as ash tuffs are found frequently. It is of interest to note that these rocks do not remain in solid outcrops anywhere within the area but must be supposed to be derived from the surface part of the volcanic ground eroded away during post-Noppi and pre-Dala porphyry times. One small granite pebble may have been an acid Rätan type, but it did not, however, contain any of the typical micro-granitic textures.

The conglomerate weathers easily at Noppikoski, while at Lusbo it seems to be more crystalline, having had to bear the enormous weight of the Dala-series in full. Its quartz-pebbles generally also exhibit more signs of optic strain than is the normal case in pebbles of the Noppi-series. Pebbles of older rock, of course, will, in both cases, retain their original optical unhomogenity. The pebbles are always very nicely rounded, angular fragments being scarce (cf. Pl. LVII).

Similar pebbles occur within the basal parts of the Dala porphyry flows too. For instance, several have been knocked out of the porphyry between Vassjöån and Älvho and in each case proved to be a sandstone quartzite of the upper Noppi-type. A single sample proved to be a quartzite unusually rich in potash-felspar, to which no counterpart has been found either with the Noppi-series or the Loos-series. Even if fully recrystallized in consequence of the heat of the enclosed porphyry, it showed very primary clastic features and may have been derived from some remote sedimentation phase of the Noppi-series.

At one locality, exposed at unusually low water in the Ore river, many pebbles were found together trapped within the porphyry. This may show that the conglomerate had not attained any greater measure of stability at the time of the extrusion of the Dala lavas, and that loose pebbles of the country rocks, which later formed the conglomerate, were picked up by the flows.

The unconformity is also evidenced by the Dala porphyries brecciating the Noppi-quartz porphyries at Tallsjön, as well as by the ash-sediments of the lower Dala-series containing badly weathered big angular fragments of the quartz porphyries (Pl. XCVII, Fig. 1). A big boulder of red Dala-porphyry enclosing a multitude of fragments of the Noppiquartzites has been photographed in the appended picture, Pl. XCVIII, Fig. 1.

The Extrusives.

LOOSTRÖM, in his paper on the sub-strata of the Dala porphyries, assumes the red porphyrite of Tunturiberget N. of Ämådalen to overlie the Noppi porphyry to the N.E., believing the lower topographical level of the latter to coincide with the stratigraphic level. Starting from this belief, he suggested an ascending succession with red porphyrite at the bottom succeeded by increasingly acid lavas and ending with red porphyries.

No contacts were found by him, and the present author, too, has looked in vain for any at Tunturiberget. Nevertheless, the writer feels confident that there is no tectonically undisturbed overlying of the quartz-porphyries by the porphyrites at that place. The tectonic picture of the whole region, as well as the strong dislocation zone separating the porphyrites from the Viidamäki and Millberget quartz-porphyries, suggests a considerable downfaulting of the former rocks. The only locality within the whole region where the magmatic contact of Dala porphyry and older rocks is observable, is E. of Tandsjö and E. of the big N.—S. fault. The »contamination» of the porphyry E. of Älvho by pre-Jotnian pebbles may be taken as being a »near contact», and the porphyry dyke cutting the Noppi-slates at Tallsjö-bäcken may suggest the composition of the earlier porphyry extrusions.

All this evidence combines to show that the earliest eruption of the Dala porphyries has been an acid or syenitic one and not a porphyritic. It would be outside the scope of this memoir to give a complete description of all the different lava flows, and the chronology of their extrusions. This would not even be possible without additional comparative research extended westwards within the large Dalecarlia porphyry area.

Very little has been published earlier on the chemistry and mineralogy of these rocks. NORDENSKJÖLD, in 1893, gave a short description (26) of some basic members of the series from Älvdalen, Orsa and Mora, taken at random, so to say, and WEIBULL, in 1897, also dealt with porphyritic types of diabases occurring as dykes at the Silfberg mines in S. Dalecarlia, outside the porphyry area proper (38). The only analyses published are two from Silfberg and four appended to the description of the geological map of Sweden, published in 1901 by the Geological Survey. These latter embrace one red porphyrite, sampled some miles S. of Helvetesfallet, and three felsitic porphyries, from Bredvad, Blyberg and Klittberg to the S.W. of the Hamra region. Only a brief note on their general mineral composition was given.

At present, the writer aims merely at giving a general survey of the most important features of the magmatic evolution, presenting for the first time a bird-eye view, so to say, of the chemical, mineralogical and metamorphic characteristics of this interesting group of rocks, an exposal which, later on, may be used as a basis for detailed studies. A selection of typical micro-photographs is also given.

When discussing the tectonics, reference has already been made to the porphyries occurring, with few exceptions, as lava flows, one above the other. Within each flow, the basal portion may be »chilled», but, generally, there is a diminishing size of grain from the bottom towards the top. Exceptions from the flow emplacement of the rocks are encountered where younger lavas on their extrusion have broken through the older beds. Such injections may be studied at Tandsjö and Älvho for instance.

The general succession of chemical changes within the flows is really not so simple as that proposed by LOOSTRÖM. There is a grading from intermediary to acid rocks within the lower Dala-series, and from strongly basic to acid within the upper series. Expressed in NIGGLI's »qz»-values, the former varies from + 10 to + 268, while the latter starts at about — 22 and ends somewhere near + 250. Reference has already been made to the separation of the two series by an inter-Jotnian erosion level, but this unconformity will here only be regarded as an interlude of no importance to the magmatic story, which will be treated of as a whole. The inter-Jotnian sedimentation, although older than the younger series, will be discussed separately in the following chapter.

The Porphyries.

The chemical composition of the earliest intrusions is given by analyses Nos. 82 and 83, from Sillakorvamäki and Örnberget respectively, the latter being the most basic representative of the older series. Both are clearly syenitic. The texture of these reddish rocks is coarsely porphyric, large phenocrysts (2—8 mm.) of tabular felspars lying within a granophyric base of felspar, some quartz and pigeonitic augite (and its metamorphic alteration products: serpentine, amphibole, chlorite and epidote). Titano-magnetite ores, titanite, fluorite and apatite are present as accessories in amounts, varying between 2 and 5 %. The potash felspar is perthitic, mostly strongly pigmented by iron oxide, but sometimes, too, quite clear. The latter type of the mineral is mostly microcline, while some of the pigmented phenocrysts may be orthoclase. The two types represent two different generations.

The average plagioclase ranges from oligoclase, An_{21}, at Örnberget, to albitic oligoclase An_{11}, at Sillakorvamäki, the phenocrysts generally being some 3—4 % richer than the composition of the plagioclase of the base. The felspar is sparsely twinned and generally not pigmented by iron-oxide. It is seldom fresh, however, generally being sericitized and occasionally containing irregular patches of fluorite. This latter mineral now and then also replaces the strings of albite within the potash felspar. The plagioclase is of two generations, one older, sometimes surrounded by potash felspar and sometimes occurring independently as strongly corroded antiperthitic crystals, and a younger one of nicely idiomorphic habit.

The pyroxene is a slightly pleochroic whitish-green pigeonitic augite of the following optic characteristics:

$$c/\gamma = 33°;\ 2V_{550} = 45° \text{ to } c/\gamma = 34°;\ 2V_{550} = 48° 30'$$

It is transformed into strongly pleochroic green chlorite and some epidote at Örnberget, while at Sillakorvamäki a green serpentine is the common alteration product. As epidote is wanting in the last case, the augite in question may, consequently, be very poor in lime.

The ground mass of the Örnberget porphyry is a fine-grained poikilitic one, still retaining nice primary flow-structures, while at Sillakorvamäki it is of a coarser, characteristic, angular grain which the writer proposes to call »micro-rapakivi» texture. The small idiomorphic orthoclase crystals, constituting the bulk of the base, are shaped like short rectangular tables, between which the quartz occupies only the interstices. Real micro-pegmatitic textures occur only occasionally. Whenever they do, the orthoclase occurs in two generations, only the older one being perthitic. The titanite of the ground mass is an alteration product of the ores.

As another exponent of the earlier porphyry extrusions there may be taken the 3—4 m. wide dyke cutting the Noppi slates at Tallsjöbäcken, N. of Noppikoski (Analyses No. 81). Megascopically, it is a very beautiful rock with 2—5 mm. large, brick-red, tabular phenocrysts of potash felspar, and a few white plagioclase; within a very sparse, dark-red felsitic base. Some of the phenocrysts consist of red shells of pigmented, slightly perthitic, orthoclase, surrounding almost white or slightly pink albitic oligoclase (An_{10}). Accessories are: pigeonitic augite, mostly altered into chlorite and pistazite, titaniferous ores and some leucoxene. The red micropoikilitic ground mass is dotted by lighter nebulous patches, richer in quartz (cf. Pl. LXVII, Fig. 1).

The rock has almost the appearance of a concentrate of felspar crystals extruded from the bottom of a magma-chamber where felspars have accumulated by differentiation. Very rich in phenocrysts, although of smaller and uneven size, is, too, the porphyry of the Knoppen and Pilkalampinoppi Hills. An analysis of the former is given as No. 79. The mineralogical composition, as well as the texture, is very similar to that of the above-mentioned dyke rock, but the ground mass is more in evidence and the pyroxene more abundant and quite fresh. These mineralogical divergencies, however, do not constitute any great difference in the chemical composition, as may be noticed by comparing the two analyses (cf. Pl. XLVII, Fig. 2).

At Älvho, a small island in the Ore älv between two diabase dykes (cf. p. 270, Fig. 17) consists of a somewhat more acid porphyry of a rather coarse granophyric base. This porphyry is, perhaps, not a flow but a feeding dyke to lava extrusions at higher level. It grades in places almost into a porphyric Rapakivi granite. Its analysis is given as No. 78. The phenocrysts are large, occasionally as much as 10 mm., and are slightly perthitic pigmented orthoclase or microcline and clear albite. The albite occurs in two generations, partly as inclusions within the potash felspar, and partly as later crystals or rims around the former — a true Rapakivi feature. The perthite-inclusions of the microcline are largely replaced by fluorite, while no fluorite is found within the albite crystals (cf. Pl. LXVI).

The base is coarsely granophyric, and the porphyry seems to represent a border case of the Rapakivi granite. It is, however, no doubt the hypabyssic, and not the abyssic, exponent of the magma. This is emphasized by several textural features, the most striking being the presence of large idiomorphic, somewhat corroded, quartz phenocrysts surrounded by zones, rich in quartz, which constitute enlarged copies of the acicular auroles of the quartz porphyries (cf. Pl. LXV). These auroles also occur around the potash felspars and may be taken as a typical hypabyssic feature incompatible with the normal Rapakivi texture. The same granophyre farther W. at Vassinkoski, about 2 km. W. of Älvho, also carries inclusions of earlier, quite recognisable, tuffitic surface rocks of the Dala series, which may be supposed to be derived from tuffitic beds between consecutive flows, cut by the feeding dyke.

Of a true porphyric habit is the violet, felsitic »hornstone»-porphyry occupying the N. island at Älvho as well as the N. shore of the Ore Älv. White albite-oligoclase (An_{10}), pink microcline phenocrysts and corrodated quartz crystals lie in a patchy poikilitic base together with a few chlorite-epidote-pseudomorphs of pyroxene. The same concentration of granophyric quartz in the groundmass around the phenocrysts is conspicuous in this instance, too.

The violet porphyry is not specially marked on the large map of this memoir but is entered in a special map (Fig. 17). It seems to occupy the same position as the granophyre, being probably a feeding dyke to flows at a higher level, representing one of the late acid members of the younger Dala-porphyry-series. A petrologically quite similar violet lava flow caps the younger series N.W. of Tandsjö at the small hill of Silverknoppen. Two comparative analyses have been made of the two rocks, Nos. 77 and 76. There is practically no chemical nor mineralogical difference between the two rocks, only some phengitic mica being present in the latter one. Texturally, the Silverknoppen porphyry displays, however, a most beautiful flow structure, clearly indicating its more extrusive character. There seems to be no doubt of the two rocks being genetically connected and contemporaneous. The spotty appearance of the base of these two rocks at crossed nicols, giving the impression of a panther skin, is due to small sponges of albite intergrown by quartz and only resolvable at a very strong magnification.

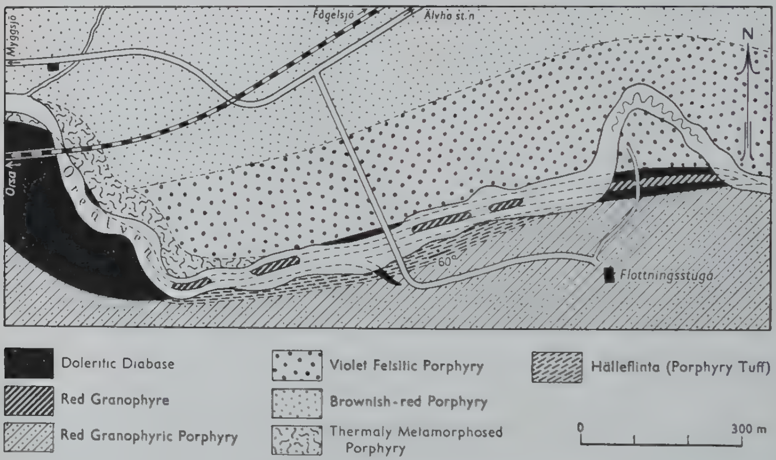


Fig. 17. Sketch map of the Ore Älv district at Älvho.

To the younger series also belongs the light-red porphyry around Gällsjön, S.W. of Tandsjö, and at Lusbo (Åmån). This rock has a very characteristic habit, a few brick-red phenocrysts lying scattered in a not quite felsitic pink base. While, within the porphyries, most of the plagioclase generally occur as phenocrysts, a large percentage in this case remains in the base. An analysis from Lusbo is given as No. 75. The orthoclase crystals are strongly pigmented, and the albite plagioclase (An_4) is slightly sericitized. Somewhat corroded quartz phenocrysts

Analysis Nr. 74.

Felsitic Porphyry, Örnberget Hill (Ls - 535).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	75.56	125.81	Q . . .	39·04	Quartz . . .	38.8	qz	+ 238	s	81.5
TiO_2	0.23	0.29	Or . .	36.75	Orthoclase . .	33.6	si	490	A	8.1
P_2O_5	tr.	—	Ab . .	16.77	Plagioclase		ti	1.17	C	0.4
Al_2O_3	13.38	13.13	An . .	1.94	$(Ab_{91}An_9)$.	18.7	al	51.0	F	1.3
Fe_2O_2	0·89	0.56	C . . .	2.65	Chlorite, Mus-		fm	8.0	a	25.0
FeO	0.24	0.33	Σ sal .	97.15	covite . . .	7.6	c	3.0	c	1.0
MnO	0.02	0.03	Hy . .	0.58	Ores and pig-		alk	38.0	f	4.0
MgO	0.22	0.55	Hm . .	0.89	mentation .	1.3	mg	0.30	n	3.3
CaO	0.38	0.68	Ilm . .	0.47		100.0	k	0.67	k	1.61
Na_2O	1.98	3.19	Σ fem .	1.94			c/fm	0.35		
K_2O	6.23	6.61	H_2O . .	0.59						
$H_2O^{+105°}$	0.59	3.27		99.68						
$H_2O^{-105°}$	0.17									
	99.89									

Quantitative System: I: 3: 1: 2 — *Magdeburgose.*
Osann's Type: No. 6. Round Mt. (s 82, a 25.5, c 1.5, f 3.0, n 3.9, k 1.67).
Or: Ab: An — 66.26: 30.24: 3.50.
Sp. gravity $^{20°}_{4°}$ C: 2.621.

Analysis Nr. 75.

Light-red Porphyry 1 km. south of Lusbo, Ämån (Ls - s - 48).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	75.22	125.24	Q . .	33.52	Orthoclase . .	36.3	qz	+ 187	s	82.2
TiO_2	0.42	0.53	Or . .	35.65	Plagioclase		si	463	A	7.3
P_2O_5	tr.	—	Ab . .	24.12	$(Ab_{96}An_4)$.	28.0	ti	1.85	C	0.5
Al_2O_3	12.16	11.93	An .	2.51	Quartz . . .	33.5	al	44.0	F	2.2
Fe_2O_3	0.67	0.42	Σ sal .	95.80	Diopside-augite	1.1	fm	6.5	a	22.0
FeO	0.55	0.77	Di . .	0.41	Titanite . . .	0.7	c	8.5	c	1.5
MnO	0.02	0.03	Wo .	1.39	$Fe(OH)_2$ . . .	0.4	alk	41.0	f	6.5
MgO	0.06	0.15	Mt . .	0.60		100.0	mg	0.35	n	4.2
CaO	1.28	2.28	Hm .	0.17			k	0.59	k	1.78
Na_2O	2.85	4.60	Ilm .	0.77			c/fm	1.28		
K_2O	6.07	6.44	Σ fem .	3.34						
H_2O^+	0.96	5.33	H_2O . .	0·96						
				100.10						
H_2O^-	0.10									
	100.36									

Quantitative System: I: 4: 1: 3 — *Grorudose.*
Osann's Type: No. 7. Mono Lake (s 81, a 23, c 1.5, f 5.5, n 5.6, k 1.64).
Or: Ab: An — 57.15: 38.66: 4.19.
Sp. gravity $^{20°}_{4°}$ C: 2.608.

Analysis Nr. 76.

Violet Porphyry from Silverknoppen Hill, west of Lake Tandsjön (Ls - 636).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	74.15	123.46	Q . . 28.88	Orthoclase	qz + 154	s 81
TiO_2	0.15	0.19	Or . . 35.03	(Microcline) 33.8	si 424	A 8.2
P_2O_5	tr.	—	Ab . . 28.84	Albite 32.1	ti 0.69	C 0.0
Al_2O_3	12.06	11.83	Σ sal . 92.75	Quartz . . . 27.5	al 40.5	F 6.5
Fe_2O_3	2.33	1.46	Ac . . 3.20	Epidote, chlo-	fm 12.0	a 23.5
FeO	0.22	0.30	Di . . 0.62	rite and seri-	c 5.0	c 0.0
MnO	0.05	0.07	Wo . 1.38	cite 4.8	alk 42.5	f 6.5
MgO	0.10	0.25	Mt . . 0.44	Ores and pig-	mg 0.09	n 5.0
CaO	0.82	1.46	Hm . 0.93	mentation . 1.8	k 0.51	k 1.57
Na_2O	3.82	6.16	Ilm . 0.29	100.0	c/fm 0.43	
K_2O	5.91	6.27	Σ fem . 6.86			
H_2O +105°	0.58	3.20	H_2O . 0.58			
			100.19			
H_2O −105°	0.08					
	100.27					

Quantitative System: I: 4: 1: 3 — *Liparose.*
Osann's Type: No. 2. Poisano Mt. (s 80.5, a 23.0, c 0.0, f 7.0, n 5.8, k 1.56).

Or: Ab: An — 54.85: 45.15: 0.00.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.653.

Analysis Nr. 77.

Violet felsitic Porphyry on »North Flottön»-Island in Ore Älv, south of Älvho Station (Ls - v - 413).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	73.91	123.06	Q . . . 31.83	Quartz . . . 32.1	qz + 180.5	s 81
TiO_2	0.30	0.38	Or . . 28.92	Plagioclase	si 434.5	A 7.5
P_2O_5	0.00	—	Ab . . 30.39	($Ab_{90}An_{10}$) . 34.4	ti 1.41	C 1.2
Al_2O_3	13.42	13.17	An . . 4.73	Orthoclase	al 46.5	F 1.7
Fe_2O_3	1.01	0.63	C . . . 0.51	(Microcline) 29.3	fm 9.0	a 21.5
FeO	0.45	0.63	Σ sal . 96.38	Chlorite . . . 1.5	c 6.0	c 3.5
MnO	0.02	0.03	Hy . . 0.68	Epidote . . . 0.9	alk 38.5	f 5.0
MgO	0.26	0.65	Mt . . 0.49	Ores and pig-	mg 0.27	n 5.3
CaO	0.96	1.71	Hm . . 0.67	mentation . 1.8	k 0.47	k 1.65
Na_2O	3.58	5.78	Ilm . . 0.60	100.0	c/fm 0.65	
K_2O	4.88	5.18	Σ fem . 2.44			
H_2O +105°	0.73	4.05	H_2O . . 0.73			
			99.55			
H_2O −105°	0.06					
	99.58					

Quantitative System: I: 4: 2: 3 — *Toscanose.*
Osann's Type: No. 13. Obsidian Cliff (s 81.5, a 23.0, c 3.0, f 6.0, n 5.3, k 1.75).

Or: Ab: An — 45.16: 47.46: 7.38.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.641.

Analysis Nr. 78.

Coarse red Granophyric Porphyry. »Southern Flottön»-Island in Ore Älv, south of Älvho Station. (Ls - v - 412).

Analysts: N. Sahlbom and H. von Eckermann (the F and CO_2 only).

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	70.80	117.88	Q	27.51	Orthoclase		qz	+ 125	s	78
TiO_2	0.45	0.56	Or	31.75	(Microcline)	32.0	si	365	A	8.1
P_2O_5	tr.	—	Ab	29.04	Albite	29.1	ti	1.85	C	1.1
Al_2O_3	14.15	13·88	An	1.12	Quartz	24.8	al	43.0	F	3.6
Fe_2O_3	0.41	0.26	C	2.34	Chlorite	7.3	fm	17.0	a	19.0
FeO	1.88	2.62	Σ sal	91.76	Epidote	4.1	c	5.0	c	2.5
MnO	0.08	0.11	Hy	4.68	Ores	1.6	alk	35.0	f	8.5
MgO	0.92	2.28	Mt	0.68	Fluorite	0.6	mg	0.42	n	4.9
CaO	0.96	1.71	Ilm	0.88	Calcite	0.5	k	0.51	k	1.43
Na_2O	3.43	5.53	Cc	0.50			c/fm	0.31		
K_2O	5.40	5.73	Fr	0.73		100.0				
$H_2O^{+105^\circ}$	0.69	3.83	Σ fem	7.42						
F	0.28	1.47	H_2O	0.69						
CO_2	0.22	0.50		99.87						
$H_2O^{-105^\circ}$	0.16									
	99.83									

Quantitative System: I: 4: 1: 3 — *Liparose.*
Osann's Type: No. 8. Betandroka (s 80.5, a 20.0, c 2.0, f 8.0, n 5.6, k 1.64).
Or: Ab; An — 51.12: 46.91: 1.97.
Sp. gravity $^{20^\circ}_{4^\circ}$ C: 2.606.

Analysis Nr. 79.

Porphyry. Knoppen Hill, Lissjöberg. (Ls - s - 88.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	66.53	110.77	Q	12.29	Orthoclase	43.0	qz	+46	s	75.0
TiO_2	0.85	1.06	Or	42.81	Plagioclase		si	296	A	9.4
P_2O_5	0.06	0.04	Ab	33.00	($Ab_{93}An_7$)	35.8	ti	2.94	C	0.7
Al_2O_3	15.25	14.96	An	2.79	Quartz	11.3	al	40.0	F	4.8
Fe_2O_3	1.65	1.03	Σ sal	91.29	Diops. augite	8.4	fm	14.0	a	19.0
FeO	1.11	1.55	Di	3.25	Titanite	1.5	a	8.5	c	1.5
MnO	0.05	0.07	Wo	0.66		100.0	alk	37.5	f	9.5
MgO	0.62	1.54	Mt	1.40			mg	0.29	n	4.5
CaO	1.72	3.07	Hm	0.67			k	0.55	k	1.20
Na_2O	3.88	6.26	Ilm	1.60			c/fm	0.60		
K_2O	7.21	7.65	Σ fem	7.58						
$H_2O^{+105^\circ}$	0.82	4.55	H_2O	0.82						
				99.69						
$H_2O^{-105^\circ}$	0.10									
	99.85									

Quantitative System: I: 4: 1: 3 — *Liparose.*
Or: Ab: An — 54.46: 41.98: 3.56.
Sp. gravity $^{20^\circ}_{4^\circ}$ C: 2.631.

Analysis Nr. 80.

Contaminated Red Porphyry cutting Porphyrite. N. W. of Tandsjö station. (Ls - 145.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	65.86	109.66	Q . . 24.15	Plagioclase	qz + 60	s 73.5
TiO_2	0.70	0.87	Or . . 24.46	($Ab_{66}An_{34}$) . . 37.2	si 248	A 6.0
P_2O_5	0.26	0.18	Ab . . 24.11	Orthoclase . . 24.9	ti 2.23	C 3.4
Al_2O_3	14.36	14.09	An . . 14.19	Quartz . . . 23.9	al 35.0	F 7.8
Fe_2O_3	3.37	2.11	Σ sal . 86.91	Chlorite . . . 6.8	fm 24.5	a 10.5
FeO	1.46	2.03	Di . . 3.46	Epidote . . . 5.5	c 18.5	c 6.0
MnO	0.04	0.06	Hy . . 2.11	Ores 1.1	alk 22.0	f 13.5
MgO	1.46	3.62	Mt . . 2.56	Apatite . . . 0.6	mg 0.36	n 5.2
CaO	4.17	7.43	Hm . 1.60	100.0	k 0.49	k 1.44
Na_2O	2.84	4.58	Ilm . 1.35		c/fm 0.75	
K_2O	4.12	4.37	Ap . . 0.65			
$H_2O^{+105°}$	1.06	5.88	Σ fem 11.73			
			H_2O . 1.06			
			99.70			
$H_2O^{-105°}$	0.36					
	100.06					

Quantitative System: I: 4: 2: 3 — *Toscanose.*

Osann's Type: No. 24. Santorin (s 71.5, a 11.5, c 6, f 12.5, n 6.4, k 1.28).

Or: Ab: An — 38.98: 38.42: 22.60.

Sp. gravity $\frac{20°}{4°}$ C: 2.719.

Analysis Nr. 81.

Porphyry Dyke. Tallsjöbäcken, north of Noppikoski. (Ls - v - 439.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	68.38	113.85	Q . . 14.42	Orthoclase . . 42.3	qz + 64	s 76.6
TiO_2	0.60	0.75	Or . . 43.52	Plagioclase	si 324	A 9.3
P_2O_5	tr.	—	Ab . . 33.00	($Ab_{90}An_{10}$) . 36.8	ti 2.13	C 0.9
Al_2O_3	15.61	15.31	An . . 3.90	Quartz . . . 15.0	al 43.5	F 3.0
Fe_2O_3	1.68	1.05	Σ sal . 94.84	Pyroxene,	fm 9.5	a 21.0
FeO	0.50	0.70	Di . . 1.06	Chlorite . . 2.6	c 7.0	c 2.0
MnO	0.03	0.02	Wo . . 0.70	Ores and pig-	alk 40.0	f 7.0
MgO	0.18	0.45	Hm . 1.68	mentation . 3.3	mg 0.15	n 4.5
CaO	1.40	2.50	Ilm . 1.01	100.0	k 0.55	k 1.26
Na_2O	3.88	6.26	Ru . . 0.09		c/fm 0.76	
K_2O	7.18	7.62				
$H_2O^{+105°}$	0.72	4.00	Σ fem 4.54			
			H_2O . 0.72			
			100.10			
$H_2O^{-105°}$	0.22					
	100.38					

Quantitative System: I: 4: 1: 3 — *Liparose.*

Osann's Type: No. 8. Betandroka (s 80.5, a 20.0, c 2.0, f 8.0, n 5,6, k 1.64).

Or: Ab: An — 54.12: 41.03: 4.85.

Sp. gravity $\frac{16°}{4°}$ C = 2.589.

Analysis Nr. 82.

Red Granophyric Syenitic Porphyry. S. E. of Sillakorvamäki Hill.
(Ls - v - 408.)
Analyst: N. Sahlbom.

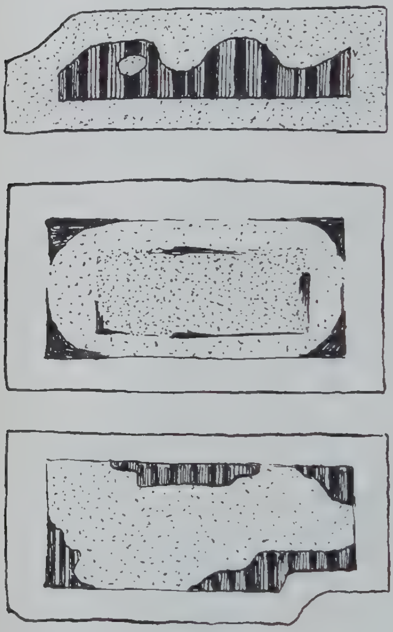
	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	63.25	105.31	Q	6.61	Plagioclase		qz	+ 14	s	71.5
TiO_2	1.10	1.38	Or	33.39	($Ab_{89}An_{11}$)	48.8	si	248	A	9.5
P_2O_5	0.25	0.18	Ab	43.25	Orthoclase	33.7	ti	3.29	C	1.6
Al_2O_3	16.91	16.59	An	6.68	Diopsidic augite	4.9	al	39.0	F	6.2
Fe_2O_3	1.76	1.10	Σ sal	89.93	Quartz	7.2	fm	17.0	a	16.5
FeO	1.79	2.49	Hy	1.10	Ores	2.5	c	10.5	c	2.5
MnO	0.05	0.07	Di	3.04	Titanite	1.9	alk	33.5	f	11.0
MgO	0.96	2.38	Mt	2.55		100.0	mg	0.34	n	5.8
CaO	2.52	4.49	Ilm	2.11			k	0.42	k	1.23
Na_2O	5.10	8.23	Ap	0.64			c/fm	0.63		
K_2O	5.65	6.00	Σ fem	9.44						
$H_2O^{+105°}$	0.78	4.33	H_2O	0.78						
				100.15						
$H_2O^{-105°}$	0.12	Quantitative System, I: 5: 2: 3 — *Pulaskose.* Osann's Type: No. 53. Masafuera (s 70, a 17.5, c 3.5, f 9, n 5.7, k 1.00).								
	100.12	Or: Ab: An — 40.09: 51.91: 8.00.								
		Sp. gravity $^{20°}_{4°}$ C = 2.671.								

Analysis Nr. 83.

Coarse Red Syenitic Porphyry at Örnberget Hill. (Ls - 539.)
Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	62.28	103.70	Q	5.89	Microcline and		qz	+ 10	s	71
TiO_2	0.89	1.39	Or	40.60	Orthoclase	42.0	si	240	A	9.5
P_2O_5	0.18	0.13	Ab	34.59	Plagioclase		ti	3.24	C	2.3
Al_2O_3	17.82	17.48	An	9.74	($Ab_{79}An_{21}$)	44.5	al	40.5	F	5.5
Fe_2O_3	1.82	1.14	Σ sal	90.82	Chlorite	4.6	fm	16.5	a	16.5
FeO	2.01	2.80	Di	1.33	Epidote	4.4	c	10.5	c	4.0
MnO	0.13	0.18	Hy	1.82	Quartz	2.2	alk	32.5	f	9.5
MgO	0.72	1.79	Mt	2.54	Ores	1.9	mg	0.25	n	4.2
CaO	2.45	4.37	Ilm	1.90	Apatite	0.4	k	0.53	k	1.22
Na_2O	4.07	6.57	Ap	0.35		100.0	c/fm	0.62		
K_2O	6.39	7.36	Σ fem	7.94						
$H_2O^{+105°}$	0.88	4.89	H_2O	0.88						
				99.64						
$H_2O^{-105°}$	0.25	Quantitative System: I: 5: 2: 3 — *Pulaskose.* Osann's Type: No. 53. Masafuera (s 70, a 17 5, c 3.5, f 9, n 5.7, k 1.00)								
	99.89	Or: Ab: An — 47.80: 46.62: 5.58.								
		Sp. gravity $^{20°}_{4°}$ C: 2.629.								

are never absent, and may sometimes be present to such an extent that the rock, microscopically, grades into a quartz porphyry. The orthoclase is somewhat perthitic and occurs in two generations, as is strikingly emphasized by Fig. 18 c), where the two generations are separated by plagioclase which has, so to say, rectified the crystal faces of the corroded older orthoclase generation. The albite, too, is sometimes present in two generations, an albite-twinned older one and a younger one sometimes exhibiting »chessboard» texture and surrounding the former.



a) Tabular orthoclase, »rectifying» corroded plagioclase phenocryst. Uttertjärnsberget.

b) Zonal tabular orthoclase phenocryst with chlorite separating the zones.
Red porphyrite of Helvetesfallet.

c) Corroded orthoclase crystal »rectified» by albite and surrounded by a later generation of orthoclase. Lusbo porphyry.

Fig. 18.

Of the remaining minerals, the pyroxene is a pigeonitic augite, and the ilmanite is mostly replaced by titanite.

Finally, a chemical example may be given of the most acid exponent of the older porphyry series by reverting to Örnberget, from the top flow of which the sample of analysis No. 74 was obtained. This analysis shows a most remarkable excess of alumina in correspondence with the chemical features of the older quartz porphyries and which is quite unexplainable when calculating the composition of the mode on the basis of the analysis. If the white mica is taken as phengitic, about half of the excess has still to be accounted for. An explanation of this excess, as originating in consequence of loss of alkalies at the extrusion, has already been given in the previous chapter, when discussing the quartz porphyries (cf. p. 246). The clearly fluidal ground mass of this porphyry is fairly coarsely micro-poikilitic. Streaks of almost pure quartz alternate with a less acid base, constituting a most characteristic fluxion structure. No tendency to any development of quartz phenocrysts is observable, however, and this seems to be a common rule of the acid members of the older porphyry series.

The analysed acid porphyries, now described, constitute only a small selection of the more striking types of the manifold varieties occurring within the district. The more granophyric, and, at the same time basal, types occupy the major part of the area between the Älvho and Flärksjön latitudes W. of the large eastern diabase dyke (cf. map Pl. CX). This area, being also characterized by the exposed intrusion of Rapakivi magmas, represents a deeper erosion level than the eastern marginal part of the porphyry area between Örnberget and Sillakorvamäki. This latter is, undoubtedly, somewhat downthrown E. of the diabase dislocation, the younger flows, consequently, being better preserved.

Every transitional phase between porphyry and granite may be observed here, and, in many cases, the granophyric bottom portions of the flows are quite undistinguishable from the granophyric marginal parts of the true abyssic granite, which generally intrude as sheets. The close relation of the porphyry to the Rapakivi is evidenced by the occurrence of oligoclase shells around orthoclase, by the occasional alteration of augite into strongly birefringent hornblende, and by the »micro-Rapakivic» angular habit of the grains of the ground mass. The pigeonitic augite, too, varies within limits similar to those of the Rapakivi ($^{c}/_{\gamma} = 40^\circ$; $2V_{550} = 59^\circ$). The Akkamäki Hills offer good opportunities for the study of these »border rocks». Törnebohm, in his day, put them down as porphyries, while Looström, from a purely petrographic point of view, claims them to be granites. The present writer sides with Törnebohm, giving the unmistakably bedded character of the rocks the preference, especially as, in many cases, a grading into real felsitic porphyries is evident.

All these granophyric porphyries belong to the older series and their gradual changes into felsitic types, not only as consecutive younger flows but also within one and the same flow, may be nicely studied in the superimposed eastern bed-escarpments of the Sillakorvamäki and Örnberget Hills. A decided concentration of felspar crystals is always noticeable towards the basal portion of the thicker flows. This differential accumulation of plagioclases rich in lime, viz, of oligoclasic or, in a few cases, andesinic composition, is for instance, conspicuous at Stora Svedjeberget and Sundsjöberget too. The two generations of potash- as well as sodic-felspars which constitute a characteristic of the Rapakivi granites (cf. p. 292) are always a regular feature of the flows, too.

As one ascends the flows, the texture changes from granophyric to spherolitic, spherolites developing within the base around the orthoclase phenocrysts. This may be observed at Sillakorvamäki especially, and also at Uttertjärnsberget, W. of Tandsjö, from which latter place Fig. 18 a) pictures the beautifully regular orthoclase tables around earlier corroded plagioclase (cf. Pl. LXIX—LXXVI).

At a still higher level within the flows the spotty micropoikilitic texture predominates, the spots at the beginning being rather large, well-defined granophyric sponges, sometimes even »antigranophyric», with radiating orthoclase crystals within the predominating quartz. At the same time the plagioclase grows more albitic and the fluorite becomes a common accessory constituent. Sometimes, enormous quantities of fluorite are found within the rocks, and fair-sized boulders have been observed, of almost pure fluorite, undoubtedly being derived from the adjoining porphyry beds. Sometimes the micropoikilitic texture assumes, megascopically, an almost banded character by the segregation of fluidal streaks of quartz. At Harjamäki, W.S.W. of Sundsjön, the very top of the ridge was mapped in the field as banded »hälleflinta», but proved, on later investigation, to be a purely eruptive rock with fluxial bands of quartz and micro-poikilitic ground mass.

The top parts of the lava flows generally grow very poor in phenocrysts, simultaneously with an increase in the density of the grain. The spongy spots of the base become smaller, and finally defy the resolving power of the microscope. Further, the base becomes almost isotropic and the last remaining phenocrysts are generally clear, beautifully crystallized orthoclases, most probably originally formed as sanidine. These sanidine pseudomorphs are not only found at Örnberget and at Sillakorvamäki but also in the porphyry of Otalampiknoppen, W. of the latter hill. In one instance, at the top of Karhumäki, the optic characteristics of sanidine still persist. This grayish yellow rock also shows relics of a vitreous texture. On the W.S.W. slope of the same hill occurs a more reddish acid porphyry where the vitreous perlite texture is fully preserved, together with relics of lithophyses and spherolites. Strongly corroded orthoclase crystals are brecciated in the undoubtedly primarily viscous obsidian glass. The devitrification has hardly been carried past the resolving power of the microscope.

Below the jotnian sediments S. of Bössfallet a red and white spotted rock crops out, which at first was taken to be a red porphyrite. The microscope investigation proved it instead to be an acid effusive porphyry of an almost vitreous fluidal isotropic base, containing kaolinized and sericitized felspar as well as quartz phenocrysts and innumerable elongated »tooth-like» vesicles, filled by a structureless colourless substance, uniaxially negative through aggregative polarization (cf. Pl. LXXXI). Refraction and birefringence are about those of quartz. The substance is left to future investigation. This strange vesicular rock may belong to the older Dala-porphyries, as suggested on the section along the Ämå valley, Pl. CIX, but its position being uncertain a note of interrogation is added.

Immediately N. of Flärksjön, within the younger Dala series, occurs a very felsitic porphyry. Another is found at the top of one of the lower flows of the older Dala series at Vassjöån. The latter is a dark-red banded rock of alternating felsitic and porphyric layers, of which the felsitic are almost crypto-crystalline, with minute spherolites and perlitic textures. Small quartz phenocrysts of typically tridymitic habit occur, together with minute rhombic grains of carbonate, probably calcite.

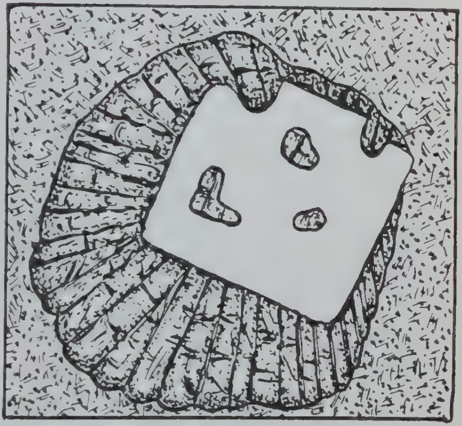


Fig. 19. Quartz phenocryst surrounded by a rim of pistazite. Quartz-porphyry E. of Örnberget. Magnification 10 diam.

Finally, a few more words may be said respecting the quartz-porphyric members of the upper Dala series. The Lusbo porphyry at the basal portions of the flows develops a granophyric quartz porphyry of unusual microscopic beauty, each well-crystallized quartz grain being a centre, or radiating symplectitic growth, of orthoclase and quartz. The perthitic inclusions of the orthoclase are replaced by calcite (cf. Pl. LXXXVI). Below Bössfallet a small outcrop of a red micropoikilitic quartz porphyry, containing no other phenocrysts but somewhat corroded quartz grains surrounded by quartz-saturated auroles, is the only exponent of this type of rock within the southern area of younger acid porphyries (cf. Pl. LXXVI). The area N. of Unån represents only the lower series of the beds, i. e., normal felsitic porphyries with acid andesinic plagioclases, and bottom portions rich in accumulated felspar phenocrysts.

E. of Örnberget, within the subsided porphyrite area, a dyke of red felsitic quartz porphyry cuts the porphyrite. In this instance the ground mass is almost micro-trachytic, minute lathes of felspar indicating the direction of flow. The quartz phenocrysts, too, are of some interest, Fig. 19 gives a picture of one of them, showing the surrounding rim of pistazite and also the inclusions of the same minerals within the quartz. A few green pigeonitic augites and felspar phenocrysts also enter into the mineralogical composition.

The Metamorphism of the Porphyries.

The porphyries are generally very slightly metamorphosed, giving the impression of well-preserved volcanic extrusives, even to the extent of their being real ryolitic brimstone lavas, which latter are preserved at the N.E. foot of Pilkalampinoppi, between two of the flows, as well as in the form of fragments in a layer of ashes separating them. The bottom portion of the upper flow is extensively contaminated by such fragments (cf. Pl. LXXXIV). Very nice red, banded ashes occur at St. Korsilampi too, on the slopes of Örnberget, presumably at the same stratigraphic level as at Pilkalampinoppi. They look very recent indeed.

Actually, the only metamorphism of the porphyries worth mentioning is the thermal influence of the doleritic diabases. At the Älvho railroad bridge the porphyry opposing the diabase W. of the river has a concentric shaly appearance, which, at first glance, suggests a tuffitic sedimentation. Closer investigation, however, shows it to be a feature accompanying the configuration of the contact between the diabase and the porphyry, extending to a depth of some 50 yards or more within the latter. Where the diabase tapers off into the narrow dykes running through the canyons of Älvho, the thermal aurole disappears. This is shown on the sketch-map Fig. 17, p. 270.

The metamorphic influence is limited to a very characteristic coarsening of the micro-poikilitic texture of the base. Instead of a coarsening of the granophyric texture, which is often regarded as a sign of thermal metamorphism, the quartz disintegrates into small rounded grains, not only within the ground mass itself but also within the granophyric or acicular auroles around the phenocrysts, and the texture assumes at crossed nicols the aspect of something like a dark sky dotted with stars. This »milky-way texture» arises wherever a micro-poikilitic or even granophyric porphyry or porphyrite comes into close proximity to any larger body of diabase. It has been observed at Lusbo, at Emådalen, at Bössfallet, Helvetesfallet, Myggsjö, Pikalampinoppi, Gönsjön, and even within the Rätan granite at Risberget (N. of Fågelsjö). The Pl. LXVIII, LXX, LXIV, Fig. 2 pictures this characteristic feature.

The texture in question is so exclusively restricted to the thermal metamorphism of the diabase that I believe it may be used in the future to trace the continuation of the diabase dykes where, at present, they are not exposed but may nevertheless exist, such as between Hästknopparna, S. of Flärksjön and Oreån, along the Oreån river towards Finnberget, etc. Unfortunately, I have not had sufficient time at my disposal for this investigation, or the brecciating net of diabases on the map would probably have been more extensive.

The Porphyrites.

Turning from the acid Dala rocks to the basic, an intermediate type, analysis No. 80, is represented by a red feeding dyke of the younger flows, cutting the green porphyrite, N.W. of Tandsjö station. It is unquestionably a hybrid rock contaminated by the earlier more basic flows, as evidenced both by its predominating andesinic plagioclase and also by the incompatibility of its NIGGLI-reference values with the general sequence of differentiation of the effusives (cf. Fig. 21, p. 288). It has even been found to contain fragments of porphyrite, and may be left out of the discussion, as being in no way typical.

The normal green porphyrites are represented by the three analyses Nos. 88—90 (cf. Pl. LXXVII). These porphyrites occur W. and N.W. of Fågelsjö, S.W. of Bössfallet and W. of Lusbo. They cap the jotnian sediments of Lustjärnsberget as well. They are fairly dense green rocks, with greenish-white plagioclase and black green phenocrysts of augite. The plagioclase ranges from An_{50} to An_{55}, and is mostly saussuritized. Orthoclase does not generally occur as phenocrysts, but may sometimes be quite conspicuous in the groundmass. Free quartz is almost always present as streaks, or granophyric sponges, in the groundmass, which latter closely resembles that of the porphyries, being homogeneously or spottedly micro-poikilitic and even sometimes almost cryptocrystalline. In some cases, however, such as N. of Kölsjö Lake (Analysis No. 89) the texture of the base on high magnification proves to be trachytic.

The pyroxene is of a greenish colour and is very seldom fresh, except where the base is trachytic. Why this should be so is difficult to explain. The porphyrites of the Kölsjö district, consequently, display very nicely crystallized augite of a pigeonitic composition, the optic values ranging as follows: $^{c}/_{\gamma} = 32°—44°$; $2V_{550} = 58°—30°$.

In most others of these green porphyrites, the augite is altered into serpentine, pistazite, and titanite, the latter indicating an original titanium content. W. of Bössfallet, the augite pseudomorphs suggest two different primary augites, one rich in lime leading to pistazite-

Analysis Nr. 84.

Red Porphyrite, Ämån. (Ls - v - 503.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	61.72	102.76	Q . .	15.11	Plagioclase		qz	+ 36.5	s	69.4
TiO_2	0.66	0.88	Or . .	26.65	(Ab_{66} An_{34})	41.0	si	222.5	A	6.5
P_2O_5	0.17	0.12	Ab . .	26.74	Orthoclase . .	26.6	ti	1.74	C	3.5
Al_2O_3	15.25	14.95	An . .	14.18	Diopsidic		al	32.5	F	10.6
Fe_2O_3	3.74	2.34	Σ sal .	82.68	Augite* . .	16.4	fm	31.0	a	9.5
FeO	2.26	3.15	Di . .	3.25	Quartz . . .	10.9	c	15.0	c	5.0
MnO	0.09	0.18	Hy . .	5.08	Ores	4.7	alk	21.5	f	15.5
MgO	2.53	6.28	Mt . .	5.36	Apatite . . .	0.4	mg	0.44	n	5.2
CaO	3.84	6.85	Ilm . .	1.23		100.0	k	0.48	k	1.23
Na_2O	3.17	5.11	Ap . .	0.34			c/fm	0.49		
K_2O	4.48	4.76	Σ fem .	15.26						
$H_2O^{+105°}$	1.57	8.72	H_2O .	1.57	* Partly metamorphosed into serpentine and epidote.					
				99.51						
$H_2O^{-105°}$	0.43									
	99.91									

Quantitative System: II: 3: 2: 3 — no name.

Osann's Type: No. 25. Popocatepetl (s 68, a 8.5, c 6, f 17.5, n 6.7, k 1.20).

Or: Ab: An — 39.45: 39.57: 20.98.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.726.

Analysis Nr. 85.

Red Porphyrite at Granvasslan, Ämån River. (Ls - s - 66.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	60.64	100.97	Q . .	11.65	Plagioclase		qz	+ 25	s	68.6
TiO_2	0.90	1.18	Or . .	28.37	(Ab_{73} An_{27})	41.9	si	217	A	7.2
P_2O_5	0.33	0.23	Ab . .	29.89	Orthoclase . .	28.2	ti	2.36	C	2.9
Al_2O_3	15.39	15.10	An . .	11.96	Pseudomorphs		al	32.5	F	11.1
Fe_2O_3	4.14	2.59	Σ sal .	81.87	of diopsidic		fm	29.0	a	10.0
FeO	1.30	1.81	Hy . .	4.41	augite (ser-		c	15.5	c	4.0
MnO	0.08	0.11	Di . .	4.12	pentine, cal-		alk	23.0	f	16.0
MgO	2.52	6.25	Mt . .	1.86	cite)	21.6	mg	0.47	n	5.3
CaO	4.06	7.24	Hm . .	2.87	Quartz . . .	5.4	k	0.47	k	1.11
Na_2O	3.54	5.71	Ilm . .	1.62	Ores	2.0	c/fm	0.54		
K_2O	4.79	5.09	Ap . .	0.91	Apatite . . .	0.9				
$H_2O^{+105°}$	2.05	11.88	Σ fem .	15.79		100.0				
			H_2O .	2.05						
				99.71						
$H_2O^{-105°}$	0.25									
	99.99									

Quantitative System: II: 4: 2: 3 — *Adamellosse.*

Osann's Type: No. 16. Ranomainty (s 72.5, a 11.0, c 4.5, f 14.5, n 6.7, k 1.35).

Or: Ab: An — 42.56: 40:41: 17.03.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.706.

Analysis Nr. 86.

Porphyrite from Nyslottsknoppen. (Ls - 629.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	57.90	96.40	Q . . 7.93	Plagioclase	qz + 9	s 65.5
TiO_2	0.62	0.77	Or . . 28.36	(Ab_{58} An_{42}) 45.7	si 189	A 6.7
P_2O_5	0.60	0.42	Ab . . 25.68	Orthoclase . . 28.4	ti 1.51	C 4.9
Al_2O_3	17.66	17.32	An . . 20.31	Augite (and	al 34.0	F 11.1
Fe_2O_3	3.04	1.90	Σ sal . 82.28	chlorite) . . 15.8	fm 29.5	a 9.0
FeO	2.61	3.63	Hy . . 8.97	Ores 5.6	c 16.5	c 6.5
MnO	0.10	0.14	Mt . . 4.44	Quartz . . . 3.1	alk 20.0	f 14.5
MgO	3.05	7.56	Ilm . . 1.20	Apatite . . . 1.4	mg 0.50	n 4.9
CaO	4.80	7.56	Ap . . 1.33		k 0.51	k 1.07
Na_2O	3.03	4.89		100.0	c/fm 0.58	
K_2O	4.78	5.07	Σ fem . 15.91			
H_2O +105°	1.52	8.44	H_2O . 1.52			
			99.71			
H_2O −105°	0.18					
	99.89					

Quantitative System: II: 5: 3: 3 — *Shoshonose.*

Osann's Type: No. 61. Mormon Mt. (s 66.5, a 11, c 5.5, f 13.5, n 6.4, k 1.02).

Or: Ab: An — 38.14: 34.55: 27.31.

Sp. gravity $^{20^\circ}_{4^\circ}$ C: 2.750.

Analysis Nr. 87.

Red Dala-Porphyrite, Libbingsberg Ridge, south of Tandsjö Lake. (Ls - 647.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	55.56	92.51	Q . . 5.83	Plagioclase	qz ± 0	s 62.5
Tio_2	0.90	1.12	Or . . 22.23	(Ab_{58} An_{42}) 46.9	si 164	A 6.0
P_2O_5	0.42	0.29	Ab . . 26.24	Orthoclase . . 22.2	ti 1.95	C 5.0
Al_2O_3	16.92	16.60	An . . 21.14	Chlorite . . . 21.8	al 29.5	F 15.2
Fe_2O_3	4.03	2.52	Σ sal . 75.44	(Pseudomorphs	fm 37.0	a 7.0
FeO	3.20	4.45	Di . . 2.85	of augite)	c 17.5	c 5.5
MnO	0.16	0.23	Hy . . 11.36	Epidote . . . 4.4	alk 16.0	f 17.5
MgO	4.50	11.16	Mt . . 5.78	Ores 2.9	mg 0.54	n 5.5
CaO	5.54	9.88	Ilm . . 1.70	Apatite . . . 0.9	k 0.44	k 1.02
Na_2O	3.12	5.03	Ap . . 0.97	Quartz . . . 0.9	c/fm 0.47	
K_2O	3.73	3.96	Σ fem . 22.66	100.0		
H_2O +105°	1.74	9.66	H_2O . 1.74			
			99.84			
H_2O −105°	0.43					
	100.25					

Quantitative System: II: 5: 3: 3 — *Shoshonose.*

Osann's Type: No. 62. S:ta Croce (s 63, a 7.5, c 6, f 16.5, n 6.5, k 0.99).

Or: Ab: An — 31.94: 37.69: 30.37.

Sp. gravity $^{20^\circ}_{4^\circ}$ C: 2.749.

Analysis Nr. 88.

Green Porphyrite at Akomäki, V. of Lillhamra. (Ls - 615.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	53.98	89.88	Q . . 8.40	Plagioclase	qz + 8	s 60.1
TiO_2	0.90	1.41	Or . . 11.11	(Ab_{48} An_{52}) 47.2	si 150	A 4.1
P_2O_5	0.15	0.11	Ab . . 22.64	Epidote . . . 22.2	ti 2.33	C 7.5
Al_2O_3	18.06	17.72	An . . 32.09	Serpentine . . 13.9	al 29.5	F 16.5
Fe_2O_3	4.60	2.88	Σ sal . 74.24	Orthoclase . . 11.1	fm 32.0	a 4.5
FeO	2.73	3.80	Di . . 10.61	Quartz . . 3.3	c 28.0	c 8.0
MnO	0.20	0.28	Hy . . 4.98	Ores 1.9	alk 10.7	f 15.5
MgO	3.82	9.47	Mt . . 5.56	Apatite . . . 0.4	mg 0.49	n 6.8
CaO	9.36	16.69	Hm . . 0.79	100.0	k 0.32	k 4.07
Na_2O	2.62	4.23	Ilm . . 1.91		c/fm 0.86	
K_2O	1.87	1.99	Ap . . 0.33			
H_2O +105°	1.52	8.44	Σ fem . 24.18			
			H_2O . 1.52			
			99.94			
H_2O −105°	0.20	Quantitative System: II: 5: 4: 4 — *Hessose.* Osann's Type: No. 63. Buffalo Peak (s 60.5, a 6, c 6, f 18, n 6.8, k 0.98).				
	100.01	Or: Ab: An — 16.87: 34.39: 48.74. Sp. gravity $\frac{20°}{4°}$ C : 2.899.				

Analysis Nr. 89.

Green Porphyrite, north of Lake Kölsjön, west of Lake Tandsjön. (Ls - 640.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	53.92	89.78	Q . . 4.75	Plagioclase	qz — 4	s 58.5
TiO_2	0.82	1.03	Or . . 14.46	(Ab_{49} An_{51}) 53.7	si 146	A 4.8
P_2O_5	0.35	0.25	Ab . . 25.67	Augite 16.3	ti 1.63	C 6.5
Al_2O_3	17.79	17.45	An . . 27.81	Orthoclase . . 14.4	al 28.5	F 18.7
Fe_2O_3	3.99	2.50	Σ sal . 72.69	Serpentine . . 7.6	fm 38.0	a 5.0
FeO	3.59	5.00	Di . . 4.39	(Pseudomorphs	c 21.0	c 6.5
MnO	0.11	0.16	Hy . . 13.39	after diopsidic	alk 12.5	f 18.5
MgO	5.30	13.15	Mt . . 5.78	augite and	mg 0.56	n 6.5
CaO	7.26	12.95	Ilm . . 1.54	olivine)	k 0.36	k 0.97
Na_2O	3.02	4.87	Ap . . 0.91	Ores 4.9	c/fm 0.53	
K_2O	2.44	2.59	Σ fem . 26.01	Quartz . . . 2.1		
H_2O +105°	1.16	6.44	H_2O . 1.16	Apatite . . . 1.0		
			99.76	100.0		
H_2O −105°	0.30	Quantitative System II: 5: 3: 4 — *Andose.* Osann's Type: No. 63. Buffalo Peak (s 60.5, a 6, c 6, f 18, n 6.8, k 0.98).				
	100.05	Or: Ab: An — 20.85: 38.22: 40.93. Sp. gravity $\frac{20°}{4°}$ C : 2.784.				

Analysis Nr. 90.

Porphyrite, N.W. of Tandsjö Station. (Ls - 144.)

Analyst: N. Sahlbom.

	%	Mol. Prop. ×100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	53.53	89.18	Q . .	9.43	Plagioclase		qz	+ 4.5	s	60
TiO_2	0.91	1.14	Or . .	16.66	(Ab_{50} An_{50})	46.9	si	156.5	A	7.2
P_2O_5	0.38	0.27	Ab . .	22.05	Orthoclase . .	16.5	ti	1.93	C	6.4
Al_2O_3	20.93	20.53	An . .	23.93	Quartz . . .	11.6	al	36.0	F	12.8
Fe_2O_3	2.77	1.73	C . .	4.79	Amphibole . .	11.6	fm	34.0	a	8.0
FeO	3.85	5.36	Σ sal .	76.86	Delessitic		c	17.0	c	7.5
MnO	0.14	0.20	Hy . .	14.04	chlorite . .	7.5	alk	13.0	f	14.5
MgO	4.16	10.32	Mt . .	3.99	Ores	5.0	mg	0.53	n	5.8
CaO	5.40	9.63	Ilm .	1.63	Apatite . . .	0.9	k	0.42	k	0.87
Na_2O	2.63	4.24	Ap . .	0.95		100.0	c/fm	0.49		
K_2O	2.80	2.97	Σ fem	20.61						
H_2O +105°	2.69	14.93	H_2O .	2.69						
				100.16						
	100.22	Quantitative System: II: 4: 3: 3 — *Harzose.*								
H_2O −105°	0.55	Osann's Type: No. 95. Ascension (s 60, a 9.0, c 7.5, f 13.5, n 6.7, k 0.84).								
	100.77	Or: Ab: An — 26.60: 35.20: 38.20.								
		Sp. grayity $\frac{20^\circ}{4^\circ}$ C : 2.748.								

Analysis Nr. 91.

Porphyrite from Korsiberget Hill. (Ls - 531.)

Analyst: N. Sahlbom.

	%	Mol. Prop. ×100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	48.21	80.27	Q . .	0.06	Plagioclase		qz	— 22	s	53.5
TiO_2	1.10	1.38	Or . .	9.41	(Ab_{48} An_{52})	49.0	si	114	A	4.1
P_2O_5	0.44	0.31	Ab . .	24.09	Augite . . .	20.8	ti	2.04	C	6.5
Al_2O_3	16.48	16.17	An . .	27.53	Epidote . . .	9.6	al	23.0	F	25.0
Fe_2O_3	8.97	5.62	Σ sal .	61.09	Orthoclase . .	9.4	fm	45.0	a	3.5
FeO	1.29	1.80	Di . .	8.68	Ores	6.9	c	23.0	c	5.5
MnO	0.25	0.35	Hy . .	14.74	Olivine (pseud.)	2.0	alk	9.0	f	21.0
MgO	7.34	18.20	Mt . .	0.93	Fluorite . . .	1.3	mg	0.58	n	7.3
CaO	9.12	16.26	Hm . .	8.31	Apatite . .	1.0	k	0.27	k	0.86
Na_2O	2.82	4.55	Ilm . .	2.11		100.0	c/fm	0.51		
K_2O	1.55	1.65	Ap . .	1.00						
H_2O +105°	1.70	9.44	Fr . .	1.33						
F	0.54	2.84	Σ fem .	37.10						
			H_2O .	1.70						
				99.89						
		Quantitative System: II: 5: 3: 4 — *Andose.*								
H_2O −105°	0.13	Osann's Type: No. 92. Kinnekulle (s 53.5, a 3.5, c 5.5, f 21.0, n 8.0, k 0.86).								
	99.94	Or: Ab: An — 15.42: 39.47: 45.11.								
		Sp. gravity $\frac{20^\circ}{4^\circ}$ C : 2.901.								

chlorite-pseudomorphs, and the other rich in magnesia, altering only into chlorite and titanite. Olivine seems in many cases to have been a primary constituent but has always been found altered into serpentine and, sometimes, amphibole, the ore skeletons clearly indicating the original outlines of the crystals (cf. Pl. LXXIX, Fig. 2). A delessitic chlorite is almost always present as minute flakes within the base, and is chiefly responsible for the green colour of the rocks.

The peculiar red porphyrites of the region were noticed already by LOOSTRÖM who assigned the altered colour to some unknown metamorphic action. The range of analyses of these rocks is illustrated by analyses Nos. 84, 85, and 87. A comparison between these analyses and those of the green porphyrites immediately shows the red ones to be more acid and the reddest of them all, at Granvasslan (Analysis No. 85), to have an unusually high $Fe_2O_3 : FeO$ ratio. Their lime content is also lower, but the main difference in the analysis, however, lies in the higher alkali percentage, and especially the K_2O, of the red porphyrites, which, in NIGGLI-values, are 21.5, 23.0, 16.0, as against 10.5, 12.5, 13.0 for the green rocks.

From a mineralogical view-point, the »red» plagioclase ranges from An_{27} to An_{42} in the analysed samples, being consequently more acid than the »green» ones. Exceptions occur, however, a porphyrite from Granvasslan having been found to contain a plagioclase of An_{50}-composition (cf. Pl. LXXVII, Fig. 2).

The red porphyrites occur only within the southern porphyritic area. N. of Noppikoski they are wanting, their stratigraphically corresponding counterparts being violet-green rocks. The peculiar change in colour which is undoubtedly associated with an oxidation of the iron cannot be placed in any relationship to the metamorphic influence of younger eruptives. The doleritic diabase was strongly suspected at first, but on the study of the contacts no confirmation was forthcoming to verify the suspicion. N.W. of Ämådalen the green porphyry borders on the diabase without any other change than the »milky-way» recrystallization of its micro-poikilitic base.

The explanation of this change of colour has to be looked for elsewhere, and may be connected with the unusual richness in potassium and volatiles, fluorite being a common accessory mineral. The porphyrite N.W. of Tandsjö (Analyses No. 90) even proved to contain topaz, a rather unusual mineral association, even if the topaz is bound to a streaky quartz enrichment within the porphyrite. The accompanying high percentage of alkalies, too, is suggestive. The author, consequently, considers that autogeneous changes within the magma itself, due to its concentration of volatiles and alkalies, potassium especially, should be made responsible for the unusual oxidation of the iron.

Actually, the first extrusions in the northern as well as the southern porphyrite area are generally of the normal green type. Only when later extrusions gradually differentiate into more acid types does the accompanying concentration of the above-mentioned elements lead to an autogeneous metamorphism. Why this should occur only within the southern area is, of course, a matter of speculation. It may be due to a somewhat varying differentiation within separate magma chambers, or it may, perhaps, be explained by the northern extrusion having taken place mainly on the surface, while the southern has mostly intruded between earlier beds. A certain support of this hypothesis is given by the clearly effusive types all being found N.W. of Tandsjö, in close connection with the porphyrites.

Analysis No. 86 represents such a vesicular rock. The base of this porphyrite is almost micro-granitic, containing a conspicuous amount of orthoclase and a pigeonitic augite with the optical characteristics: $^{c}/_{\gamma} = 34°—35°$, $2V_{550} = 62° 15'$ $n_{\beta,\,550} = 1.67$. The pyroxene is partly changed into a green chlorite, the plagioclase is lathe-shaped, somewhat zonal, An_{42-45}, and there is an abundance of violet fluorite in the vesicles.

The effusive types which dominate the district N. and N.W. of Kölsjön mostly have, however, a micro-trachytic base and andesinic felspar, and also contain a large percentage of ilminite ores. The phenocrysts are lathe-shaped, 0.4—0.5 mm. long. The vesicles are filled by fluorite, quartz and pink manganese-epidote. Even pseudomorphs of olivine occur in spite of the acidity of the rocks,serpentine and amphibole ($^{c}/_{\gamma} = 16°$) being the alteration products (cf. Pl. LXXVII, Fig. 1).

At Noenoppi, E. of Örnberget, there occurs a remarkably green acid porphyrite, or rather porphyry of trachytic, partly poikilitic texture, the phenocrysts being oligoclase, augite, ores and a predominating percentage of fairly small chlorite crystals. Not all the effusive types, however, are acid. At Korsiberget, a strongly vesicular violet rock proved to contain the normal plagioclase of the green porphyrites, viz, An_{52}. As shown by analysis No. 91, it is very rich in augite ($^{c}/_{\gamma} = 27.5°$, $2V_{550} = 46°$) as well as in epidote, which latter is of the pink manganese variety, and fills the blowholes together with quartz and violet fluorite, constituting a very striking picture when seen under the microscope. The ground mass is partly clearly micro-ophitic, strongly reminding one of the texture of the marginal parts of a diabase (cf. Pl. LXXIX). When first discovered, the rock was actually mapped in the field as effusive diabase. On the other hand, the top of the same flow at the

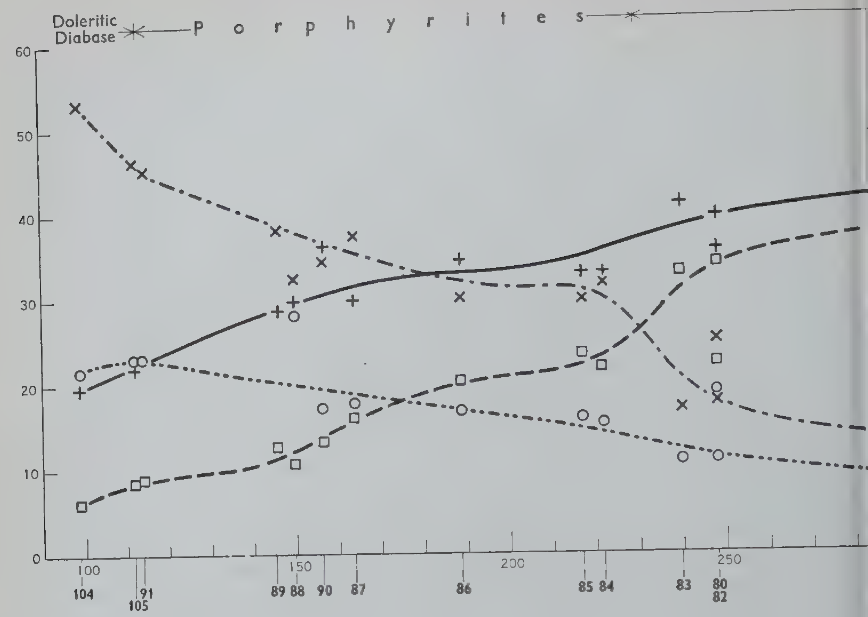
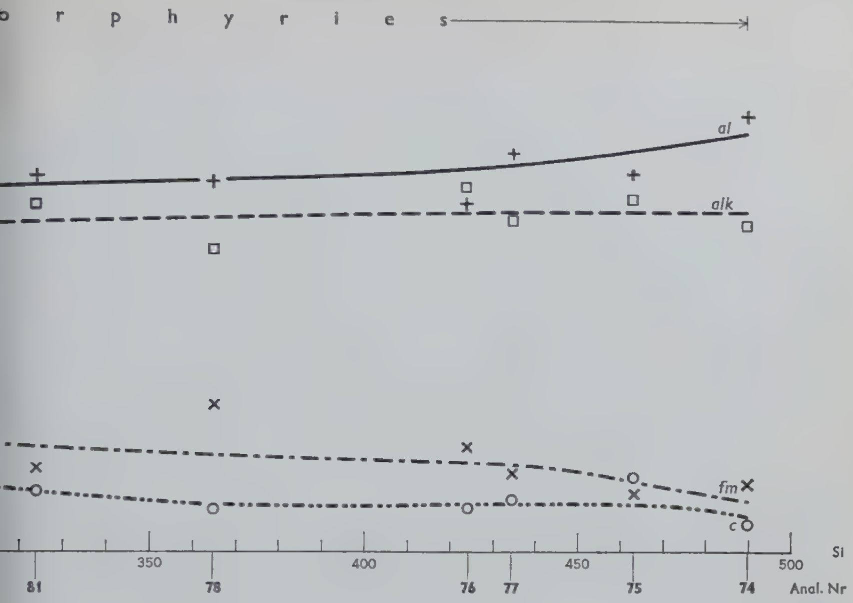


Fig. 20. NIGGLI diagram of

crest of the hill grades into a more acid type with no diabasic features whatever, the felspar phenocrysts being only andesine, An_{32}, and free quartz scattered all through the almost cryptocrystalline base. At very high magnification, the ground mass proves to be trachytic. The pigeonitic augite ($^{c}/_{\gamma} = 30°—31°$, $2V_{550} = 42°—41°$) occurs together with pseudomorphs of serpentinized olivine.

While, within the Kölsjö area, the last acid flows of the younger series directly overlie the effusive porphyritic surface rocks, the Ämån area shows a more consecutive grading into increasingly acid types. Sometimes the green porphyrites are even wanting altogether, such as is the case at Lusbo rapids where the Lusbo porphyry rests on inter-jotnian sediments. Between Unån and Emådalen, the later volcanic period seems to have started with more intermediary porphyries grading into the acid types. This may, of course, be due to primary local restrictions in the extension of the flows, and does not necessarily imply a different age of the petrologically corresponding lavas.

The red porphyrites of Helvetesfallet—Emådalen—Tunturiberget are all really of rather acid type and of every conceivable transitional composition grading to the real porphyrites. The plagioclase ranges from An_{40} to An_{26}, orthoclase or microcline phenocrysts appearing in



the effusive Dala Series.

inverse proportion to the basidity of the rock. Occasionally, the potash felspar is zonal, with varying degrees of pigmentation and green chlorite marking the boundaries between the zones (cf. Fig. 18 b). The pyroxene ranges from $c/\gamma = 20^\circ$, $2v_{550} = 40^\circ$ to $c/\gamma = 26.5^\circ$, $2V_{550} = 10^\circ$.

The Metamorphism of the Porphyrites.

The re-crystallization of the ground-mass, originating in the thermal influence of the doleritic diabase, is the only exogeneous metamorphism of the porphyrites which has been observed.

A fairly extensive autogeneous metamorphism occurs, however, leading to epidotization of the plagioclase and augite phenocrysts and to serpentinization, chloritization or amphibolitization of the augites and the olivine. This metamorphism is generally more advanced in the upper parts of the lava-flows than in their basal portions. It is generally followed by an albitization of the felspars, even if real albite-rocks comparable with those of the Loos-greenstones have not been observed.

Occasionally this late-magmatic differentiation is accompanied by concentrations of pyrites. This is, for instance, the case at Börningsberget Hill, S.W. of Sjöändan, where the vesicles of an effusive porphyrite are filled with chalcocite and chalcopyrite. The chalcocite is surrounded by rims of malachite.

The Chemical Composition of the Extrusives.

On comparing the analyses of the Dala-effusives with those of the neo-volcanic rocks, the acid porphyries agree fairly well with the liparitic magmas, only the $K_2O : Na_2O$-ratio generally being considerably higher, — a commonly occurring difference between the paleo-volcanic and the neo-volcanic extrusives of the lime-alkali-series.

The syenitic members of the basal series, analyses 82 and 83, on the other hand, are decidedly alkali-syenitic, as is, too, clearly expressed by their position in the quantitative classification. Their analyses are almost identical with that of the umptekite from Beverly, Mass. (cf. Element der Gesteinlehre p. 150), and the Niggli reference values correspond to the typical average composition of the grano-syenitic magmas, including the potash-nordmarkite of Wolf Hill and the potash-pulaskite of Lakobé.

The green porphyrites may be compared with normal andesites (cf. Elem. der Gesteinlehre, Analysis No. 15, p. 409) or with Niggli's »normal dioritic» magmas. It is more difficult to find any true equivalent to the red porphyrites. In Rosenbusch's terminology they may be named trachy-andesites, and in Niggli's either normal syenitic or monzonite-syenitic magmas. Actually, they do not quite agree with either of these groups.

The Niggli diagram is given in Fig. 21. It is remarkably symmetrical, the plotted points combining into smooth curves representing the differentiation. To the dissentient anal. No. 80 reference has already been made (cf. p. 281).

The Rapakivi Granite.

The jotnian granites of the region, referred to by the author as the Rapakivi group, differ in many respects from the normal type of the Finnish Rapakivis, their characteristic texture, viz., the rounding of the orthoclases and their surrounding by oligoclase being mostly absent. Only outside the present map farther to the W. in Dalecarlia are granite types found, the so-called Garberg granite, where the white oligoclase shells are striking features on fractured rock-surfaces as rings around the red orthoclase phenocrysts.

The Hamra rocks in hand specimens have a greater resemblance to the Strömsbro Rapakivi N. of Gävle, the Lappee granite of the

Finnish Lappeenranta region or some of the fine-grained Åland Rapakivi types.

Two different types may be recognized within the present area, the red Sandsjö granite and the grayish Loberg granite. Microscopically, the difference is not a great one, being mainly confined to a different degree of iron-oxide pigmentation.

The dominating felspars in hand specimens are the red phenocrysts of potassic felspar, partly orthoclase and partly minutely twinned microcline, but in most cases the slides, as well as the analyses, show the plagioclase to be actually the ruling felspar-phenocryst. The orthoclase is generally strongly pigmented by iron-oxide, even to the extent of making optical determinations almost impossible; porphyritically, it appears in a fine-grained ground mass, surrounded by micropegmatite or granophyric zones of felspar and quartz. Actually, the rock should be more accurately classified as a porphyric Rapakivi granophyre. The same remark applies to the above-mentioned Strömsbro Rapakivi. The orthoclase (respectively microcline) is generally strongly perthitic and occurs mostly in two generations, the latter without any plagioclase inclusions (cf. Fig. 22). This is especially the case with the Sandsjö type where the later potash felspar, too, also forms occasional shells round the plagioclase. These shells, however, are seldom complete, and real shells of small albitic grain are observed only

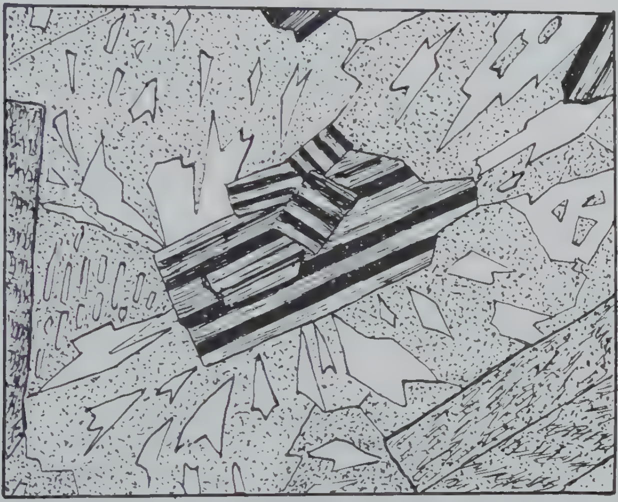


Fig. 21. Rapakivi granite. Perthitic orthoclase tables and homogeneous orthoclase of a second generation, intergrown with quartz. Magnification 10 diam.

within the reddish granites associated with the Loberg type, as seen, for instance, at the road leading up to the Loberg village, W. of Älvho.

The plagioclase, too, is in many types richly pigmented by iron-oxide, so that, megascopically, the plagioclase shells, even when present, are not apparent. In the gray Loberg type, the plagioclase is almost unpigmented, which accounts for the grayish colour of the rock. There are two generations of plagioclase as well, one sometimes occurring as inclusions within the other. At Loberget, the older generation constitutes granular shells around the orthoclase, while the younger generation is conspicuous as angular lathes in the granophyric base last solidified. While the older plagioclase may be an acid oligoclase (An_{10-12}), the one last crystallized is generally almost a pure albite (An_{2-4}) (cf. Pl. XC—XCII).

The quartz-felspathic base always includes minor percentages of chloritized green hornblende together with some biotite and muscovite titanite, magnetite, fluorite and apatite. Occasionally — for instance at Hemberget W. of Oreälv and farther N. at Siikamäki Hill — primary crystals of hypersten are still present, although mostly converted into hornblende. The violet fluorite is a never absent occupant of the last crystallized interstices of the ground mass. The felspars and the quartz of the ground mass frequently present idiomorphic faces, — a truly Rapakivic characteristic enhanced by the occurrence of the two felspars as well as of the quartz in two generations (cf. Wahl, 36, p. 105). The most acid members of the Rapakivi series represented at Loberget, are strikingly miarolitic, nicely crystallized allanites and titanites as well as a few unaxial optically positive zenotime crystals being specially noticeable.

The quartz of the very coarse ground mass of these acid rocks increases at times to a predominating amount, the red felspar being confined to the interstices between the generally idiomorphic quartz, this leading to a texture which may tentatively be called »antigranophyric».

The quartz of the Rapakivi is always optically homogeneous, indicating the absence of any dynamical stress affecting the rocks after their emplacement.

Femic minerals occur only accessorily. The augite is pigeonitic ($^{c}/\gamma = 39°$, $2V_{550} = 58°$, $(\gamma - \alpha)_{550} = 0.030$) and is mostly altered into hornblende or biotite. Hypersten has been observed occasionally.

The chemical range of composition is given by the appended analyses Nos. 92—98 as well as by the Niggli diagram, Fig. 23. In this latter, the reference values of the Strömsbro Rapakivi, the Lappeenranta porphyric Rapakivi and the averages of the Viborgite and Pyterlite Rapakivis, as computed by Wahl, are entered too. While the first-named Swedish Rapakivi agrees nicely with the differentiation sequence of the Hamra granites, the line being only somewhat lower, the Finnish Rapakivis show distinctly high »c» and »fm» values as well as lower »alk». So, too, does the Rapakivitic average magma of NIGGLI (cf. 2, p. 101) which WAHL criticized as being more nearly related to the alkali-lime-granites than to the potassic granites. He emphasized the position of the Rapakivis and, especially of the pyterlites, as being the end member of the acid rocks richest in potassium, and this remark may be said to apply in the case of the Loberg granites also. The low »mg» value of the acid members of the Hamra rocks is another striking characteristic shared in common with the Rapakivi magmas.

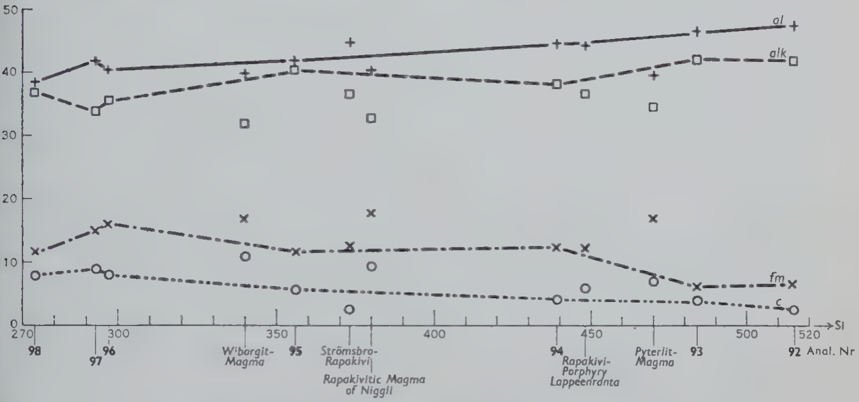


Fig. 22. NIGGLI diagram of the Rapakivi granites.

All evidences, consequently, — tectonic, chemical, mineralogical and textural — go to show the true Rapakivi character of these rocks, and there is no reason why, in future, they should not be classified as Rapakivis.

In the diagram of the age-sequence of the Loos-Hamra region, the writer has indicated Rapakivis of two different ages, one being the parental magma of the lower Dala porphyries, and the other of the upper. This division is based on the presence of granite pebbles of Sandsjö type in the conglomerates of Bössfallet. Field evidence is wanting, however, of granites cutting either the upper porphyry series or the conglomerates. The postulation of such a granite is based solely on the information supplied by LOOSTRÖM and other colleagues, of its presence farther W. of the map. The Rapakivi granites plotted on the map have, consequently, all been given the same colour, even if some happen to be of different age. Chemically and microscopically they are all alike, and it is, at present, impossible to distinguish them

Analysis Nr. 92.

Miarolitic Acid Rapakivi Granite from Loberget. (Ls - v - 419.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	77.29	128.69	Q . .	37.84	Quartz . . .	37.3	qz	+245	s	84
TiO_2	0.09	0.11	Or . .	28.36	Albite		si	515	A	7.0
P_2O_5	0.00	—	Ab . .	29.37	($Ab_{97}An_3$) .	30.8	ti	0.40	C	0.8
Al_2O_3	12.24	12.01	An . .	1.69	Microcline . .	27.1	al	48.0	F	1.0
Fe_2O_3	0.73	0.46	C . .	0.71	Muscovite and		fm	7.0	a	24
FeO	0.34	0.47	Σ sal .	97.97	some Chlorite	4.1	c	2.5	c	3
MnO	0.01	0.01	Hy . .	0.28	Magnetite . .	0.4	alk	42.5	f	3
MgO	0.10	0.25	Mt . .	0.85	Titanite . . .	0.3	mg	0.15	n	5.3
CaO	0.36	0.64	Hm .	0.15		100.0	k	0.48	k	1.88
Na_2O	3.48	5.61	Ilm .	0.16			c/fm	0.35		
K_2O	4.78	5.07	Σ fem	1.44						
H_2O^{+105}	0.46	2.55	H_2O .	0.4						
				99.87						
H_2O^{-105}	0.30									
	100.14									

Quantitative System: I: 3: 1: 3 — *Alaskose.*

Osann's Type: No. 10. Unter Mecklenburg (s 82.5, a 23, c 3.5, f 3.5, n 4.6, k 1.83).

Or: Ab: An — 47.73: 49.43: 2.84.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.608.

Analysis Nr. 93.

Fine-grained Rapakivi Granite. Sandsjö Hill. (Ls - 851.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	76.63	127.61	Q . .	35.43	Quartz . . .	36.3	qz	+206	s	83
TiO_2	0.10	0.12	Or . .	30.06	Plagioclase		si	484	A	7.3
P_2O_5	0.00	—	Ab . .	30.38	(Albite		ti	0.38	C	0.8
Al_2O_3	12.67	12.43	An . .	1.66	$Ab_{97}An_3$) . .	31.5	al	47.0	F	1.0
Fe_2O_3	0.73	0.46	C . .	0.61	Orthoclase and		fm	6.5	a	24
FeO	0.36	0.50	Σ sal .	98.14	Microcline .	26.3	c	4.0	c	2.5
MnO	0.01	0.01	Hy . .	0.21	Muscovite (some		alk	42.5	f	3.5
MgO	0.09	0.22	Mt . .	0.87	Chlorite) . .	4.0	mg	0.12	n	5.5
CaO	0.61	1.09	Hm .	0.15	Magnetite . .	1.1	k	0.48	k	1.79
Na_2O	3.57	5.76	Ilm .	0.17	Fluorite . . .	0.5	c/fm	0.65		
K_2O	5.10	5.41	Fr . .	0.48	Titanite . . .	0.3				
$H_2O^{+105^\circ}$	0.20	1.10	Σ fem	1.88		100.0				
F	0.20	1.05	H_2O .	0.20						
				100.22						
$H_2O^{-105^\circ}$	0.03									
	100.30									

Quantitative System: I: 4: 1: 3 — *Liparose.*

Osann's Type: No. 4. Milford (s 82.5, a 24, c 2, f 4, n 5.4, k 1.74).

Or: Ab: An — 48.40: 48.92: 2.68.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.568.

Analysis Nr. 94.

Rapakivi Granite from Ore ån, N.W. of Älvho. (Ls - 587.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	74.33	123.76	Q . .	33.46	Microcline . .	31.0	qz	+185	s	81
TiO_2	0.30	0.47	Or . .	30.60	Quartz . . .	32.4	si	439	A	7.6
P_2O_5	0.10	0.07	Ab . .	27.76	Albite		ti	1.77	C	0.7
Al_2O_3	12.98	12.73	An . .	2.50	$(Ab_{97}An_3)$.	28.6	al	45.0	F	2.2
Fe_2O_3	0.77	0.48	C . .	1.02	Chlorite . . .	5.4	fm	12.5	a	20.0
FeO	0.82	1.14	Σ sal .	95.34	Titanite . . .	1.1	c	4.0	c	2.0
MnO	0.04	0.06	Hy . .	1.54	Ores	1.1	alk	38.5	f	8.0
MgO	0.52	1.29	Mt . .	1.14	Apatite . . .	0.2	mg	0.37	n	4.8
Ca_2O	0.66	1.18	Ilm .	0.67	Fluorite . . .	0.2	k	0.51	k	1.65
Na_2O	3.26	5.26	Ap . .	0.26		100.0	c/fm	0.34		
K_2O	5.17	5.49	Σ fem	3.61						
$H_2O^{+105°}$	0.66	3.66	H_2C .	0.66						
				99.61						
$H_2O^{-105°}$	0.13									
	99.74									

Quantitative System: I: 4: 1: 3 — *Liparose.*

Osann's Type: No. 5. Elk Peak (s 81, a 20.5, c 2, f 7.5, n 5.0, k 1.69).

Or: Ab: An — 52.28: 45.61: 4.11.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.605.

Analysis Nr. 95.

Rapakivi Granite at Point 462, the top of the hill. North of the road north of Loberget Hill. (Ls - v - 450 a.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	70.40	117.22	Q . .	21.02	Albite		qz	+92.5	s	78
TiO_2	0.39	0.49	Or . .	37.33	$(Ab_{97}An_3)$.	36.0	si	356.5	A	8.9
P_2O_5	tr.	—	Ab . .	34.60	Microcline . .	34.9	ti	1.52	C	0.3
Al_2O_3	14.11	13.84	An . .	1.39	Quartz . . .	21.8	al	42.0	F	3.5
Fe_2O_3	1.43	0.90	Σ sal .	94.34	Chlorite . . .	3.6	fm	11.5	a	21.0
FeO	0.90	1.25	Di . .	1.45	Magnetite . .	2.0	c	5.5	c	0.5
MnO	0.02	0.03	Mt . .	1.82	Titanite . . .	1.0	alk	41.0	f	8.5
MgO	0.27	0.67	Hm .	0.16	Fluorite . . .	0.7	mg	0.18	n	4.9
CaO	0.99	1.77	Ilm .	0.74		100.0	k	0.51	k	1.36
Na_2O	4.08	6.58	Fr . .	0.68			c/fm	0.47		
K_2O	6.35	6.74	Σ fem	4.85						
$H_2O^{+105°}$	0.41	2.28	H_2O .	0.41						
F	0.29	1.53		99.60						
$H_2O^{-105°}$	0.16									
	99.80									

Quantitative System: I: 4: 1: 3 — *Liparose.*

Osann's Type No. 17. Sogneskollen (s 78, a 19.5, c 5, f 5.5, n 7.7, k 1.47).

Or: Ab: An — 50.91: 47.19: 1.90.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.604.

Analysis Nr. 96.

Syenitic Rapakivi Granite at Myggsjöbäcken. (Ls - v - 416.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	66.62	110.92	Q	14.30	Plagioclase		qz	+55.5	s	75
TiO_2	0.67	0.84	Or	38.41	($Ab_{88}An_{12}$)	38.4	si	297.5	A	8.9
P_2O_5	0.16	0.11	Ab	33.52	Orthoclase and		ti	2.14	C	1.2
Al_2O_3	15.42	15.13	An	5.00	Microcline	33.6	al	40.5	F	4.9
Fe_2O_3	1.23	0.77	Σ sal	91.23	Quartz	17.0	fm	16.0	a	18.0
FeO	1.87	2.60	Di	2.29	Hornblende and		c	8.0	c	2.5
MnO	0.09	0.13	Hy	1.95	Chlorite (with		alk	35.5	f	9.5
MgO	0.65	1.61	Mt	1.80	some biotite)	7.0	mg	0.27	n	4.8
CaO	1.73	3.09	Ilm	1.25	Magnetite	1.8	k	0.52	k	1.23
Na_2O	3.94	6.36	Ap	0.33	Titanite	1.8	c/fm	0.53		
K_2O	6.51	6.91	Σ fem	7.62	Apatite	0.4				
$H_2O^{+110°}$	0.98	5.44	H_2O	0.98		100.0				
				99.84						
$H_2O^{-110°}$	0.31									
	100.18									

Quantitative System: I. 4: 1: 3 — *Liparose.*
Osann's Type: No. 12. Alby (s 79, a 17.5, c 3.5, f 9, n 4,4, k 1.62).
Or: Ab: An -- 49.93: 43.57: 6.50.
Sp. gravity $\frac{20°}{4°}$ C: 2.617.

Analysis Nr. 97.

Coarse Syenitic Rapakivi Granite. Loberget Hill, south of Myggsjöbäcken Brook. (Ls - v - 450.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	65.95	109.81	Q	16.04	Orthoclase		qz	+57	s	74.5
TiO_2	0.60	0.75	Or	38.38	(Microcline)	35.5	si	293	A	8.8
P_2O_5	0.12	0.09	Ab	31.44	Albite		ti	2.11	C	1.9
Al_2O_3	16.18	15.89	An	5.56	($Ab_{93}An_7$)	34.7	al	42.0	F	4.0
Fe_2O_3	1.62	1.02	C	1.02	Quartz	16.5	fm	15.0	a	18.0
FeO	1.43	1.99	Σ sal	92.44	Hornblende,		c	9.0	c	4.0
MnO	0.10	0.14	Hy	1.85	biotite,		alk	34.0	f	8.0
MgO	0.58	1.44	Mt	2.33	chlorite	8.1	mg	0.25	n	4.6
CaO	1.85	3.30	Ilm	1.16	Magnetite	2.3	k	0.54	k	1.23
Na_2O	3.70	5.97	Ap	0.29	Titanite	1.6	c/fm	0.60		
K_2O	6.47	6.87	Fr	0.96	Fluorite	1.0				
$H_2O^{+105°}$	0.38	2.11	Σ fem	6.59	Apatite	0.3				
F	0.40	2.11	H_2O	0.38		100.0				
				99.41						
$H_2O^{-105°}$	0.29									
	99.67									

Quantitative System: I: 4: 1: 3 — *Liparose.*
Osann's Type: No. 12. Alby (s 79, a 17.5, c 3.5, f 9.0, n 4.4, k 1.62).
Or: Ab: An — 50.91: 41.71: 7.38.
Sp. gravity $\frac{20°}{4°}$ C: 2.636.

Analysis Nr. 98.

Red Syenitic Rapakivi Granite, close to Tallsjöbäcken (brook). (Ls - v - 449.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	65.08	108.36	Q . .	9.19	Orthoclase and Microcline .	45.0	qz	+26	s	73.5
TiO_2	0.74	0.93	Or . .	45.04			si	274	A	9.9
P_2O_5	0.04	0.03	Ab . .	34.10	Albite ($Ab_{86}An_4$) .	34.7	ti	2.28	C	0.1
Al_2O_3	15.46	15.17	An . .	1.67			al	38.5	F	6.5
Fe_2O_3	2.19	1.37	Σ sal .	90.00	Quartz . . .	7.0	fm	16.5	a	18.0
FeO	1.39	1.94	Di . .	4.15	Chloritized Hornblende	5.8	c	8.0	c	0.0
MnO	0.11	0.16	Wo . .	0.58			alk	37.0	f	12.0
MgO	0.69	1.71	Mt . .	2.32	Epidote . . .	3.4	mg	0.26	n	5.6
CaO	1.70	3.08	Hm .	0.63	Magnetite . .	2.2	k	0.56	k	1.11
Na_2O	4.04	6.52	Ilm .	1.39	Titanite . . .	1.7	c/fm	0.46		
K_2O	7.59	8.06	Σ fem	9.07	Apatite . . .	0.2				
H_2O+110°	0.80	4.44	H_2O .	0.80		100.0				
				99.87						
H_2O−110°	0.38									
	100.21									

Quantitative System: I. 5: 1: 3 — *Phlegrose.*

Osann's Type: No. 29. Tonseås (s 72.5, a 20.5, c 0.0, f 9.5, n 6.8, k 1.00).

Or: Ab: An — 55.74: 42.20: 2.06.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.618.

from each other. The writer's earlier view of the Loberg massive's belonging to the younger group, as expressed on his preliminary map 1934, is substantiated only by the find of a few strongly metamorphosed inclusions within the gray Loberg granite, supposed to be of original porphyritic composition. This assumption may be true but is better left for future consideration when more is known of the district S. and W. of the present map.

Finally, a few words may be said as to the relationship between the Rapakivi granites and the Dala porphyries. All the field evidence combines to show the parental character of the granite. The granophyric base of the thicker flows of porphyry, and the actually observed grading of such granophyric porphyry into granite, with no interposing megmatic joints — as seen N.W. of Älvho and N. of Myggsjö — hardly allow of any other interpretation.

Reference has already been made to the difficulty, not to say the impossibility in many cases, of determining petrologically what is granite and what originally may have been part of a porphyry flow. Only the field observations of the tectonic emplacement of the rocks are conclusive. Close attention has to be paid to the position of the chilled, sometimes aplitic, sometimes porphyric, contact zones of the granite in relation to the bedding planes of the almost identical granophyric flows. Even then, mistakes are not excluded, as the granite magma may have been intruded along the bedding planes of earlier porphyry flows. In many cases the joints are so blurred that an intrusion within still hot effusives must be assumed.

Such an intimate connection between granite and porphyry indicates one continuous epoch of eruptive activity, and the earlier conception of the Rapakivis having intruded »post festum», so to say, when the porphyries were all nicely congealed and cool, becomes untenable. Microscopically, one continuous series of thin slides can be laid down side by side, grading from the dense felsitic porphyry to the coarsest granite, without any possibility of finding on examination where the true porphyry ends and the granite begins.

Even chemically, too, the same gradual transition is displayed by the appended Niggli diagrams. Figs. 20, p. 289 and 22, p. 293, in which the granites and the porphyries overlap but follow identically the same trend of differentiation. It is evident that, chemically, they are the same rocks, the one, solidified on the earth surface, or nearly so, the other congealed under hypabyssal or abyssal conditions, — the different lava flows, so to say, reflecting the contemporaneous differentiation in the magma chambers underneath.

No lengthy period, allowing of advanced differentiation, separates the parental magma and its effusives, as such an interval would undoubtedly have led to discrepancies in the diagram. The intrusion of granite at the time when some of the lava flows still retained part of their initial heat, as well as the transition from granite to porphyry, corroborates this view, and this has led me, when taking into calculation the tectonic level of the porphyry caps N.N.E. of Myggsjö, to assume a rise of the granitic magma in those parts as high as 1,000—600 ft., or less, below the actual surface of those days. The old conception of very deep erosion being necessary for the exposal of the granites may, consequently, not always correspond to actual facts.

This new point of view is of great importance for the following discussion of what was previously termed the sub-jotnian unconformity, as it does away with the very deep erosion of 6,000—10,000 ft. supposed to have taken place for the uncovering of the Rapakivi granites.

The Jotnian Sediments.

The jotnian sediments within the Hamra region are almost all of inter-jotnian age and have been deposited during a considerable interval in the magmatic activity, in which period erosion removed some of the earlier lava flows. Only the conglomerates and sandstone N. of Djurberga and E. of Myrberget, may be late-jotnian, the tuffitic quartz-porphyritic hälleflintas underbedding the sediments not being connectible either with the younger or the older acid porphyries. Megascopically, they look true quartz porphyries, but microscopically they are found to be mostly tuffs with small quartz pebbles. In one locality, at Skräddaredjurberga, a thin bed of volcanic glass has been found, crowded with ash and crystal fragments, but the chronologic position remains undecided (cf. Pl. LXXXIII). There is one single piece of evidence, however, pointing to a post-porphyry age i. e., the occurrence, in the basal conglomerates underneath the sandstone, of fragments of the very granophyric quartz porphyry previously identified within the younger porphyries at Lusbo (cf. p. 279, Pl. LXXXVII). A future extension of the survey S. of the present map will probably supply the definite answer to the question of the age of these sediments. Sandstones of late jotnian age occur only a few miles S. of Helvetesfallet, below the railway bridge crossing the Åmån River, and a connection between these sandstones and the Djurberga area ought to be obtainable. For the present, the Djurberga-sediments may be taken as late-jotnian (cf. Pl. LXXXVIII).

Meanwhile, the investigation of the sediments has been concentrated on the undisputably inter-jotnian strata. These latter crop out below the younger porphyrites, from Sjöändan in the N. all the way down to Tallsjöbäcken at Oreälv. They are exposed in the Åmån valley, too, at the two Bössfallet waterfalls, along the foot and crest of Lillskogberget, at Lusbofallet and in the Lustjärnsberget hillock, S. of Åmådalen. Exposures are found along the road to Orsa, in the river bed of Unån and along the Åmån river from Emådalen to the waterfalls of Helvetesfallet (cf. Pl. LXXXV).

The most striking of the localities, as well as those the most easily visited, are the lower and upper Bössfallet and the Lusbo rapids, to which a new road trafficable by motor car now exists. Together, these localities include the whole sedimental sequence.

At the lower Bössfallet, on the S.W. shore of the river bed, gray tuffitic sediments, too, lie above the effusive porphyry previously described (cf. p. 279). These tuffitic schists are sometimes banded — pink and greenish layers alternating — and concentrations of magnetite grains within certain zones are conspicuous. Ascending the series, occasional, rounded pebbles of porphyry are met with, until the sediments turn fairly abruptly into enormous conglomerates. These accumulations of rounded pebbles, with very little gritty matrix cementing them together, reach a thickness of not less than 30—40 m. Sometimes the pebbles grow to the size of real boulders.

This conglomeratic sedimentation has been known to occur at Digerberget and other localities within the heart of Dalecarlia, and has been termed Digerberg conglomerate, or Digerberg sandstone. LOOSTRÖM interpreted them as a volcanic formation, produced by the rolling of rock fragments in the gas stream issuing from volcanic vents, and the text-books generally describe them as interformational tuff deposits. Already in my preliminary report of 1934 I corrected this erroneous conception, and was the first to suggest an inter-jotnian age for the sediments.

Further research has amply verified this hypothesis. The writer has spent days at Bössfallet examining thousands of pebbles, an unusual opportunity being offered in 1934 when a new channel was blasted through the conglomerates in order to facilitate the floating of timber. Unfortunately, the strange beauty of the rapids meandering among dozens of small islands, was destroyed at the same time, but the appended photographs taken before the operations were started (cf. Pl. CI—CII) may give some idea of the earlier erosion channel. The result of the classification of about 1,200 pebbles is given below:

Older acid Dala porphyries	49.0	%
Older effusive Dala »	32.0	»
Older syenitic Dala »	8.0	»
Quartz porphyries	6.0	»
Quartzites	4.0	»
Pre-jotnian basal conglomerate	0.50	»
Rätan granite	0.25	»
Older granites and gneiss granites	0.25	»
Total	100	%

Not a single pebble of green porphyrite was found and only one small pebble of a fine-grained diabase. Of the Rätan granite, a big boulder (about one m³) protruded from the conglomerates and was recorded on the photograph, Pl. CII, Fig. 1, before it underwent destruction. A few additional, smaller pebbles were uncovered during the blasting operations. Two of the pebbles recorded as syenitic porphyry were almost, but not quite, »Rapakivic». Two other pebble scould just as well have been Rapakivi granite as porphyry.

The classification of the pebbles shows that the erosion must have occurred mainly within the volcanic area itself, only a very small percentage of older rocks having been mixed up with the local pebbles. The great percentage of effusive surface-rocks also strongly suggests a locally restricted erosion.

Analysis Nr. 99.

Tuffitic Ore-banded Ash-sediment, crest of Lillskogberget, (Ls - v - 542).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	50.41	83.93	Q	4.70	Amphibole and some calcite, partly epidotized	40.6	qz	+ 3
TiO_2	1.08	1.35	Or	12.78	Plagioclase $(Ab_{45}An_{55})$	40.0	si	131
P_2O_5	0.13	0.09	Ab	13.61	Orthoclase	12.7	ti	1.98
Al_2O_3	14.61	14.33	An	26.06	Ores	6.5	al	21.0
Fe_2O_3	5.66	3.55	Σ sal	57.15	Apatite	0.3	fm	47.0
FeO	5.91	8.23	Hy	13.29		100.0	c	25.0
MnO	0.25	0.35	Di	17.10			alk	7.0
MgO	6.69	16.59	Mt	8.26			mg	0.51
CaO	9.77	17.42	Ilm	2.09			k	0.48
Na_2O	1.58	2.55	Ap	0.30			c/fm	0.54
K_2O	2.14	2.27	Σ fem	41.04				
$H_2O^{+105°}$	1.43	7.94	H_2O	1.43				
				99.62				
$H_2O^{-105°}$	0.18							
	99.84							

Quantitative System: III: 5: 4: 3 — (Rang Auvergnose)
Or: Ab: An — 24.36: 25.95: 49.69.
Sp. gravity $^{20°}_{4°}$ C = 2.993.

Analysis Nr. 100.

Ash-tuff from Sandsjöån river. (Ls - 610.)

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	56.47	94.02	Q	8.53	Plagioclase $(Ab_{64}An_{36})$	49.4	qz	− 2
TiO_2	0.90	1.12	Or	22.25	Orthoclase	22.2	si	174
P_2O_5	0.20	0.14	Ab	30.92	Ores	10.9	ti	2.04
Al_2O_2	17.62	17.28	An	20.29	Pyroxene and amphibole	10.1	al	32.0
Fe_2O_3	6.41	4.01	C	0.10	Quartz	6.9	fm	35.0
FeO	3.56	4.95	Σ sal	82.09	Apatite	0.5	c	14.0
MnO	0.12	0.17	Hy	5.87		100.0	alk	19.0
MgO	2.31	5.73	Mt	9.26			mg	0.30
CaO	4.25	7.58	Ilm	1.69			k	0.41
Na_2O	3.65	5.89	Ap	0.37			c/fm	0.42
K_2O	3.75	3.89	Σ fem	17.19				
$H_2O^{+105°}$	0.62	3.44	H_2O	0.62				
				99.90				
	99.86							
$H_2O^{-105°}$	0.30							
	100.16							

Quantitative System: II: 5: 3: 3 — *Shoshonose.*
Or: Ab: An — 30.29: 42.09: 27.62.
Sp. gravity $^{20°}_{4°}$ C = 2.786.

Analysis Nr. 101.

Tuffitic Jotnian Sandstone, Upper Börsfallet, Emån. (Ls - v - 476.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System	
SiO_2	73.10	121.71	Q	46.25	Quartz	38.7	qz	+ 235
TiO_2	0.34	0.53	Or	28.89	Plagioclase (Albite)	8.9	si	433
P_2O_5	0.10	0.07	Ab	8.92	Orthoclase	29.0	ti	1.88
Al_2O_3	11.97	11.74	C	4.89	Diopside, augite, amphibole	19.4	al	41.5
Fe_2O_3	3.06	1.92	Σ sal	88.95	Fluorite	2.2	fm	27.5
FeO	0.46	0.64	Hy	3.29	Apatite, ores	1.8	c	6.5
MnO	0.08	0.11	Mt	0.48		100.0	alk	24.5
MgO	1.31	3.25	Hm	2.74			mg	0.42
CaO	1.05	1.87	Il	0.74			k	0.71
Na_2O	1.06	1.71	Ap	0.27			c/fm	0.24
K_2O	4.85	5.15	Fr	1.37				
H_2O^+	1.69	9.38	Σ fem	8.99				
F	0.49	2.58	H_2O	1.69				
				99.63				
H_2O^-	0.37							
	99.93							

Quantitative System: I: 3: 2: 2 — *Mihalose.*
Or: Ab: An — 76.41: 23.59: 0.00.
Sp. gravity $^{20^\circ}_{4^\circ}$ C = 2.688.

Analysis Nr. 102.

Jotnian Dala Sandstone, Lusbo Rapids. (Ls - s - 468.)

Analyst: H. von Eckermann.

	%	Mol. Prop. × 100	Actual mineral composition %	
SiO_2	84.70	141.03	Quartz and grains of acid porphyry	68.2
TiO_2	0.31	0.39	Perthitic potash-felspar	24.6
P_2O_5	tr.	—	Sericitic mica	5.4
Al_2O_3	8.16	8.01	Ores	1.3
Fe_2O_3	0.90	0.56	Iron-oxide pigmentation, etc.	0.5
FeO	0.66	0.92		100.0
MnO	—	—		
MgO	0.16	0.40		
CaO	0.21	0.38		
Na_2O	0.20	0.32		
K_2O	4.12	4.37		
H_2O + 105°	0.60	3.33		
H_2O − 105°	0.10	—		
	100.12	Sp. gravity $^{20^\circ}_{4^\circ}$ C = 2.676		

Analysis Nr. 103.

Jotnian Dala Sandstone, eastern shore of Helvetesfallet. (Ls - v - 537.)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Actual mineral composition %	
SiO_2	85.53	142.41	Quartz	69.6
TiO_2	0.24	0.30	Perthitic orthoclase	22.5
P_2O_5	tr.	—	Sericitic mica	6.1
Al_2O_3	7.65	7.50	Ores	1.2
Fe_2O_3	1.10	0.69	Iron-oxide pigmentation, etc.	0.6
FeO	0.46	0.64		100.0
MnO	0.01	0.01		
MgO	0.37	0.92		
CaO	0.20	0.36		
Na_2O	0.22	0.36		
K_2O	3.53	3.75		
H_2O + 105°	0.72	4.00		
H_2O − 105°	0.14	—		
	100.17	Sp. gravity $^{20^\circ}_{4^\circ}$ C = 2.678		

Within the upper part of the conglomeratic beds occur layers of homogeneous fine-grained sediments, dipping slightly S.S.E. towards the overlying green porphyrite. The contact between the porphyrite and the sediments is magmatic, the porphyrite even exhibiting a chilled bottom zone. The fine-grained sediment has been analysed (Analysis No. 101) and its Niggli-values calculated. They show an increase of heavy femic minerals and a loss of alkalic ones, indicating a fair advance in the weathering of the then existing rock-ground. The norm is computed, too, in order to show the lack of correspondence with the magmatic rocks and to further emphasize the impossibility of the earlier theory of a volcanic origin. Microscopically, of course, lots of fragments of porphyries are found together with the quartz grains, but this may be normally expected in the case of an early sedimentation of detritus-material within young eruptive areas (cf. Pl. CII, Fig. 2).

At Bössfallet, the sedimentation has been cut off by the porphyrite before it could register any very advanced erosion, but at Lusbo and at Helvetesfallet the gradual disappearance of the porphyry fragments may be observed, as well as the evolution of the sparagmitic sandstone. Analyses No. 102 and 103 clearly indicate a complete breaking down of the country rocks, the grains undoubtedly being derived, not only from the older porphyries but also from the granites. Optically unhomogeneous quartz grains may be traced to the old archæan gneiss granites (cf. Pl. LXXXIX).

The sediments N. of Bössfallet, on the other side of the big E.W. fault, (cf. p. 146) are exposed along the river bed and are similar to the one of the lower Bössfallet, only being more greenish in colour, due to the presence of chlorite. Microscopically, they are composed of rounded optically homogeneous quartz grains and of fragments of porphyry cemented together by fine ashes. This sedimentation has unmistakably taken place under water, as is evidenced by the flow-structures of the ashes between the fragments, even »micro-current beddings» have been observed. Identically the same texture is encountered in the ash-deposits on the eastern shores of Tandsjö Lake, excepting that quartz grains are almost absent, the sediments, consequently, being mapped as tuffs. S. and E. of Lillhamra river, younger levels of the same sediments, fairly rich in quartz pebbles, are exposed, thus giving a motive for their being recorded as jotnian sandstones.

The top of Lillskogberget is of special interest. The fairly quartzose sediments which, in the hill, measure an unbroken and undisturbed vertical succession of not less than 110 m. thickness, are here interfoliated by beds of rather basic ashes. The ashes consist of small, even grains of grayish porphyry groundmass, and crystal fragments cemented by amphibolitic substance; vesicular fragments, rich in mangan-epidote being conspicuous. The felspars of the groundmass, on very high magnification, have been found to be of about An_{55} composition, indicating their affinity with the green porphyrites. The ashes may be supposed to register the inauguration of the late-jotnian porphyritic renewal of the volcanic activity. The ashes are banded, layers of rounded magnetite grains being quite conspicuous. Analysis No. 99 gives the chemical composition.

It is interesting to note that, in this case, the ashes have evidently not been resedimented, as the analysis, recalculated in NIGGLI-values, agrees nicely with the porphyrite from Korsiberget, analysis No. 91. The same may be said about the green ash tuffs, too, at Sandsjöån stream, analysed as No. 100. These ashes are almost free from pure quartz grains. The NIGGLI-values of the analysis compare favourably with those of the red porphyrites, analysis No. 87, for instance.

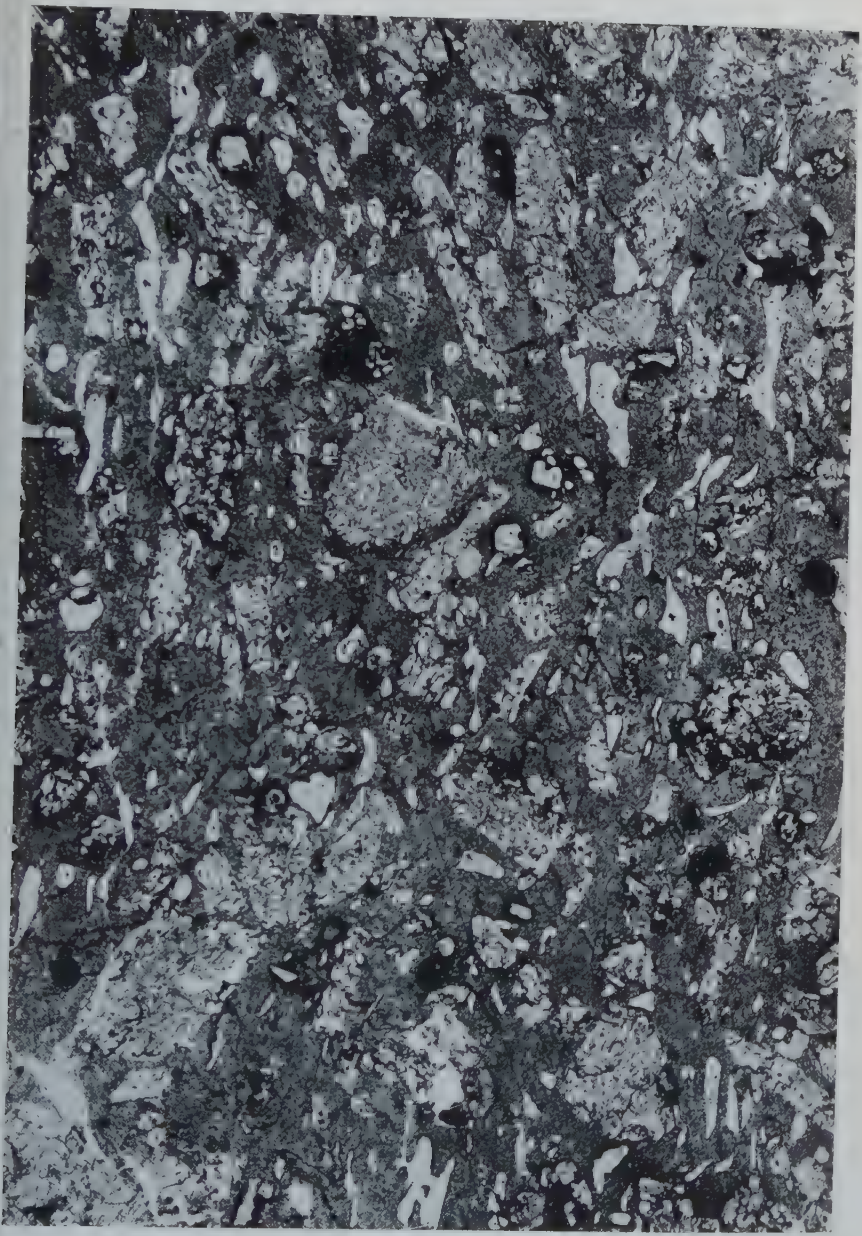
Finally, the whole sequence from the tuffitic bottom layers through beautiful conglomerates and more quartzose sediments may be studied at a third locality by those who care to climb the steep S.W. face of Lustjärnsberget. At the same time they will have the advantage of crossing the basal conglomerates of the Dala series deposited on the eroded surface of the Rätan granite, and of admiring a splendid view from the top of the hill.

Small remains of the series are encountered at a few places within the region where they have been preserved by down-faulting. Only two of these are large enough to be reproduced on the map, viz, the one at Tallsjöbäcken, which is derived from a layer fairly high up in the succession, containing about 30 % of rounded quartz grains, and the other one at Flärksjön representing almost pure sandstone.

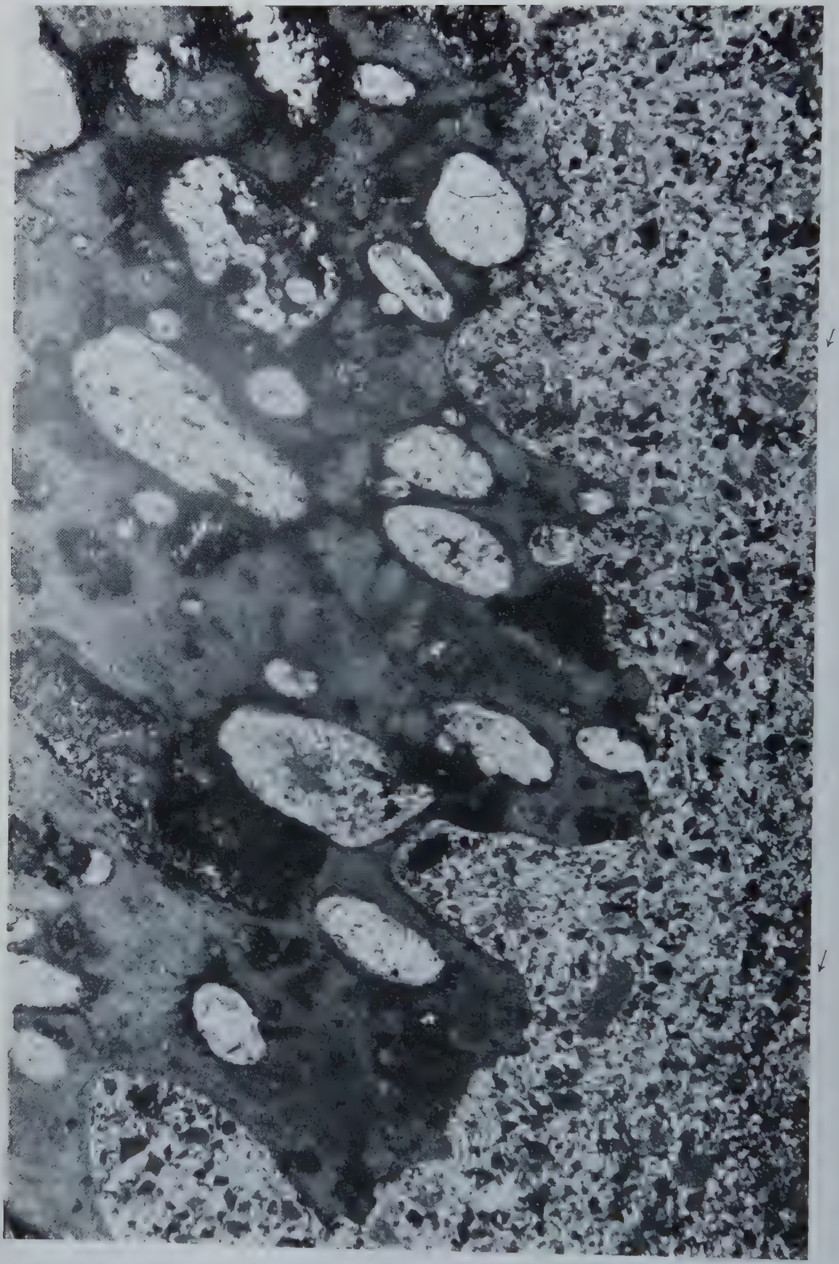
The Doleritic Diabase.

The Normal Type.

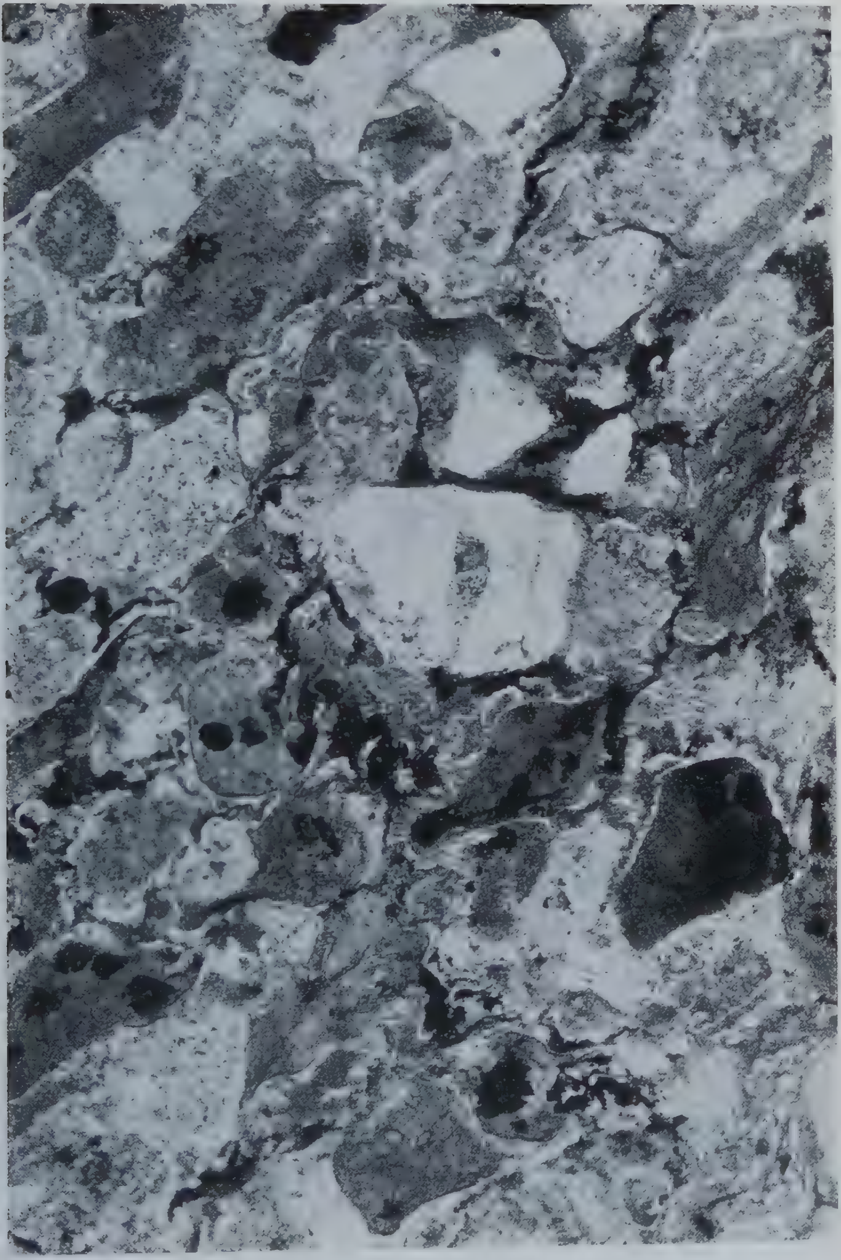
This rock has not previously been known to occur over any large areas within the region covered by the map, only a few short dykes having been indicated by LOOSTRÖM in his sketch map. Farther S. and W., however, where the intrusive Åsby diabase and extrusive Öje diabase interfoliate and cap the great jotnian sandstone area of Dalecarlia, they were earlier made the subject of special studies by TÖRNEBOHM in 1882 and OLIVECRONA in 1920. LOOSTRÖM, in 1919, described the field relations of an Åsby diabase dyke intruding into the Dalecarlian sandstones along their bedding planes, and inter-



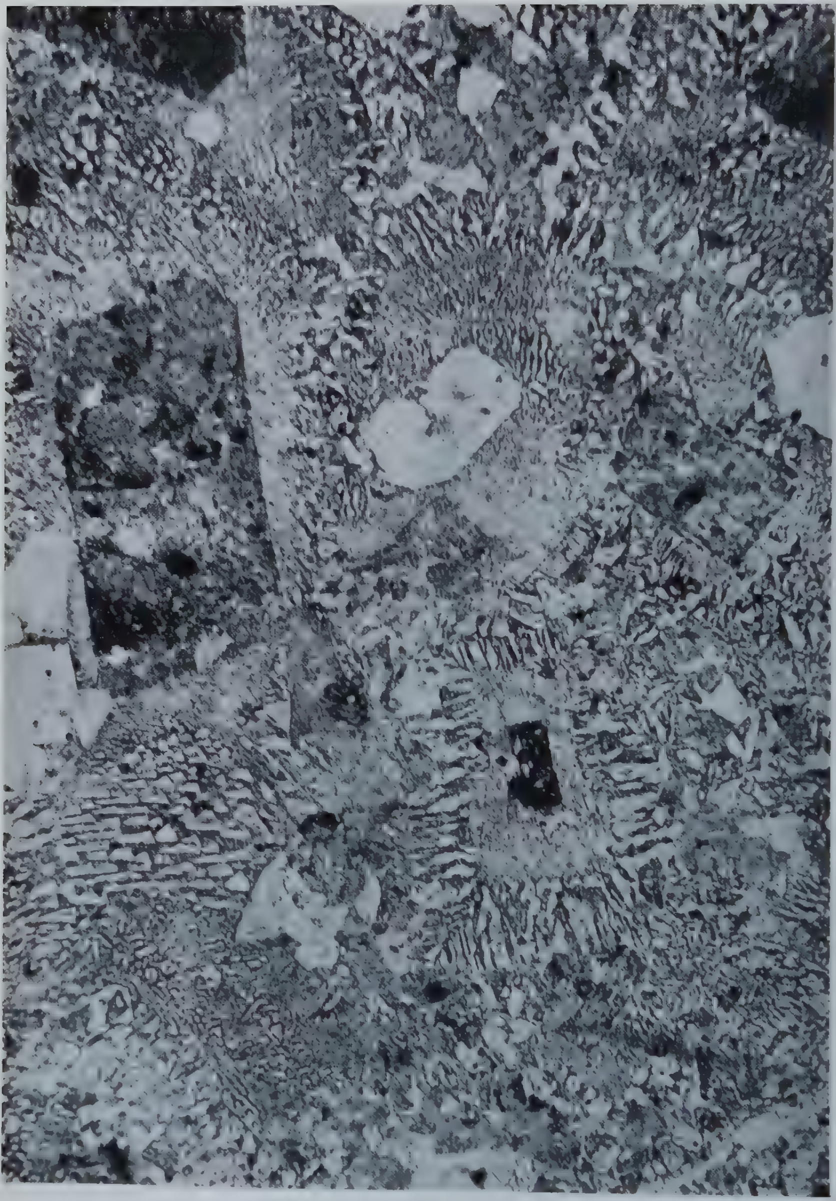
Effusive red porphyry at Ämån. Tooth-shaped vesicles and sericitized felspars in an almost isotropic base. Ord. light. Magnif. × 8.



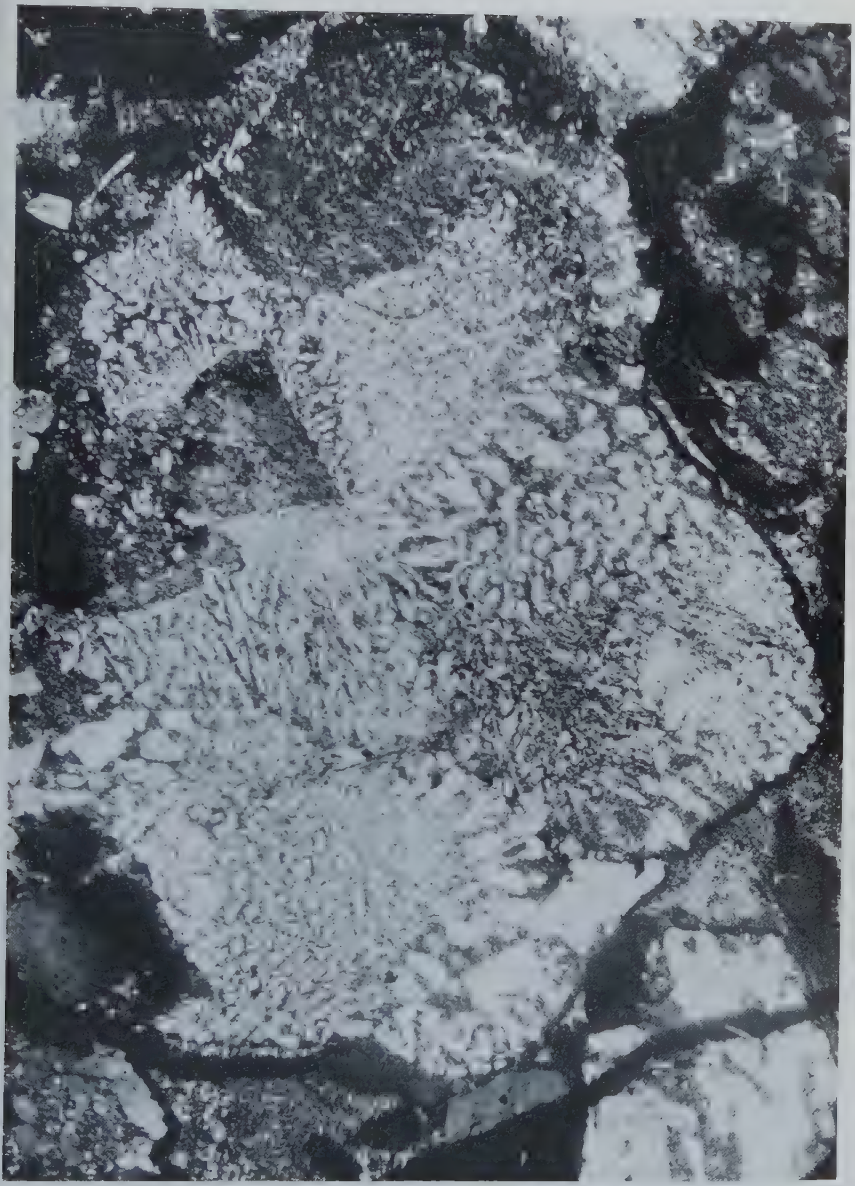
Fragment of brimstone in tuffitic jotnian sediments, Tandsjö. Arrows indicate planes of sedimentation. Ord. light. Magnif. × 8.



Tuffitic Jotnian sediment from the E shore of Lake Tandsjön.
Ord. light. Magnif. × 55.



Granophyre at Lusbo, belonging to the younger Dala porphyries. In the centre and on the right are idiomorphic quartz-phenocrysts.
Nic. +. Magnif. × 40.



Pebble of Lusbo granophyre within Jotnian conglomerates at Djurberga.
Nic. +. Magnif. × 40.

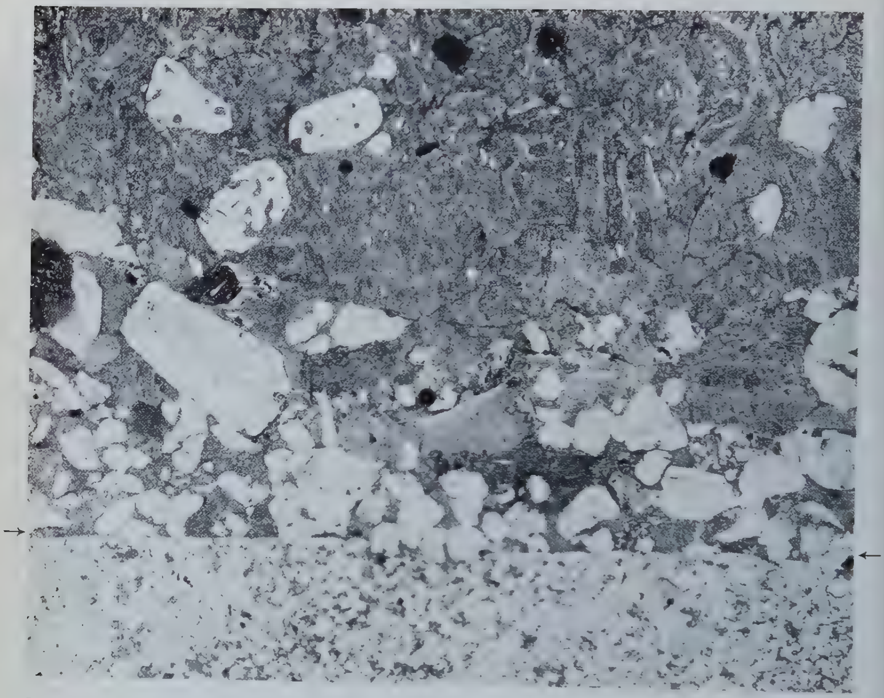


Fig. 1. Jotnian sediments at contact (arrows) to porphyry, from Villsjöarna. Basal portion of sediments rich in quartz grains. Ord. light. Magnif. × 10.

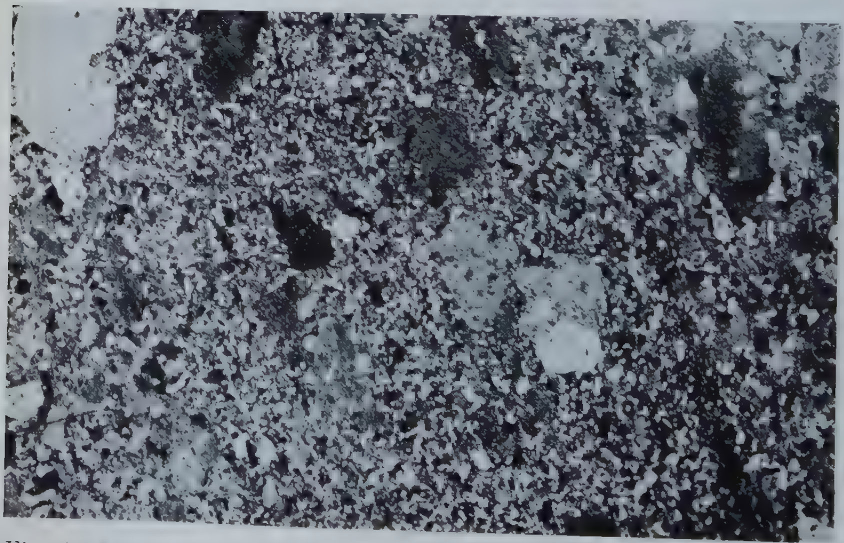
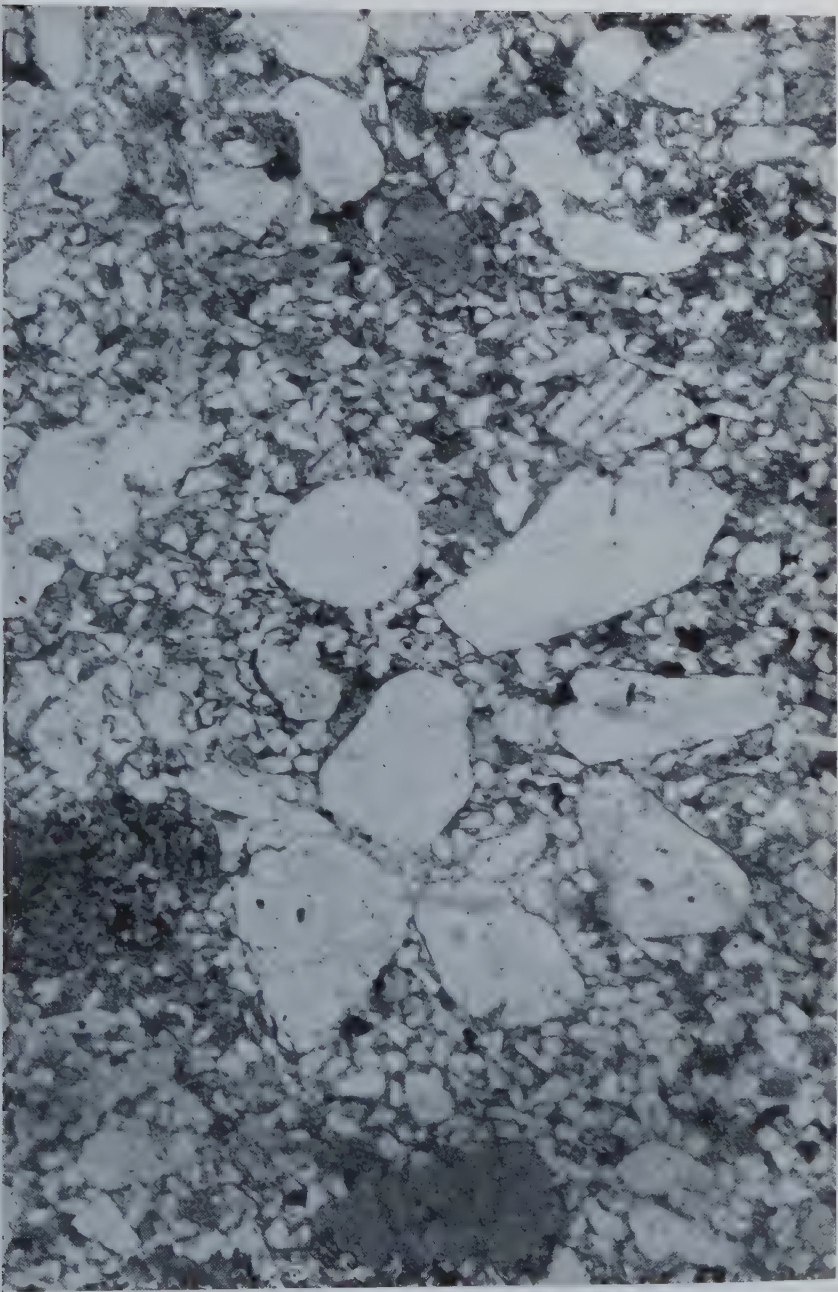


Fig. 2. Quartzose Jotnian sediments at Djurberga. Light-gray and dark-gray larger grains consist of porphyry- and porphyrite fragments respectively. Ord. light. Magnif. × 10.



Jotnian sandstone at Helvetesfallet. The three big dark grains are felsitic porphyry. Ord. light. Magnif. × 55.

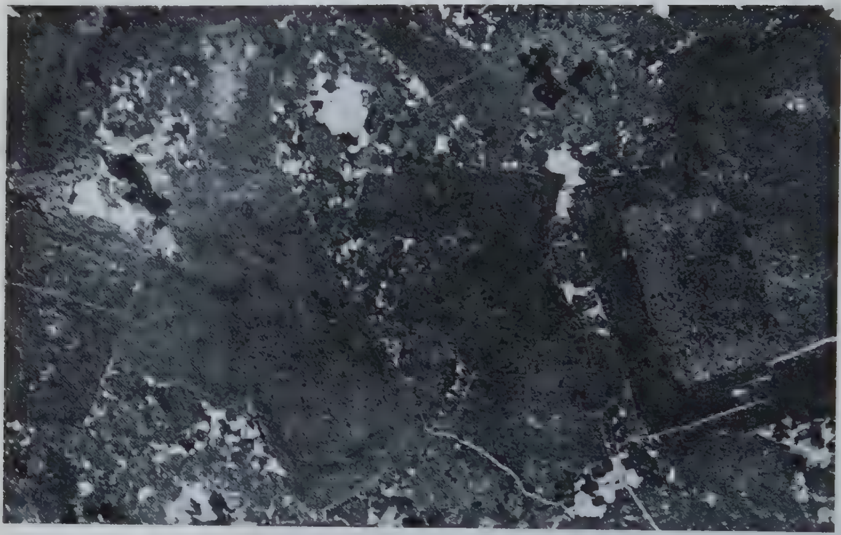


Fig. 1. Syenitic Rapakivi granite from Tallsjöbäcken. To the right, orthoclase shells around plagioclase. Ord. light. Magnif. × 10.

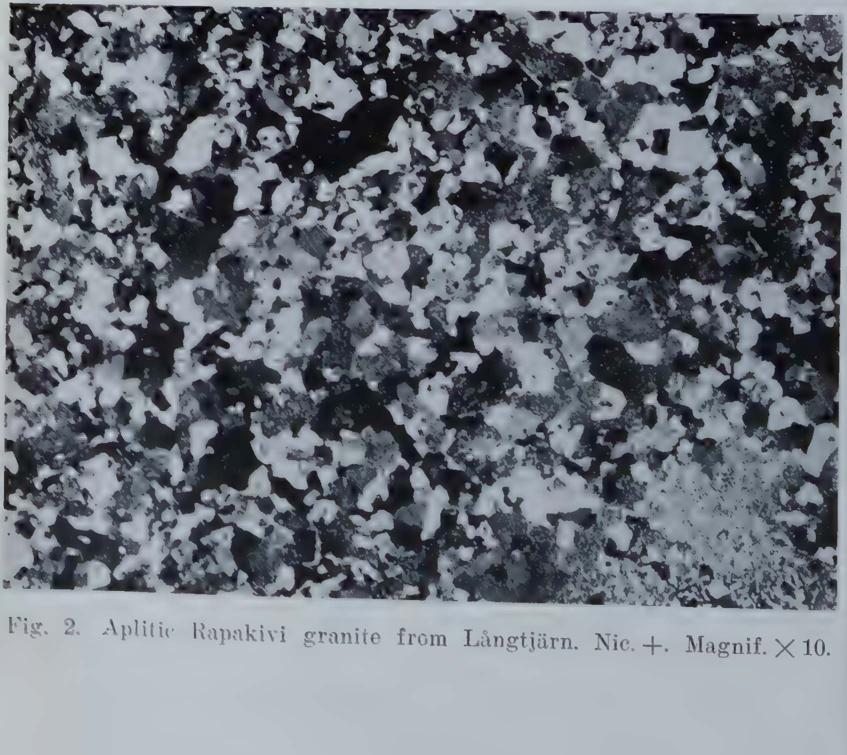
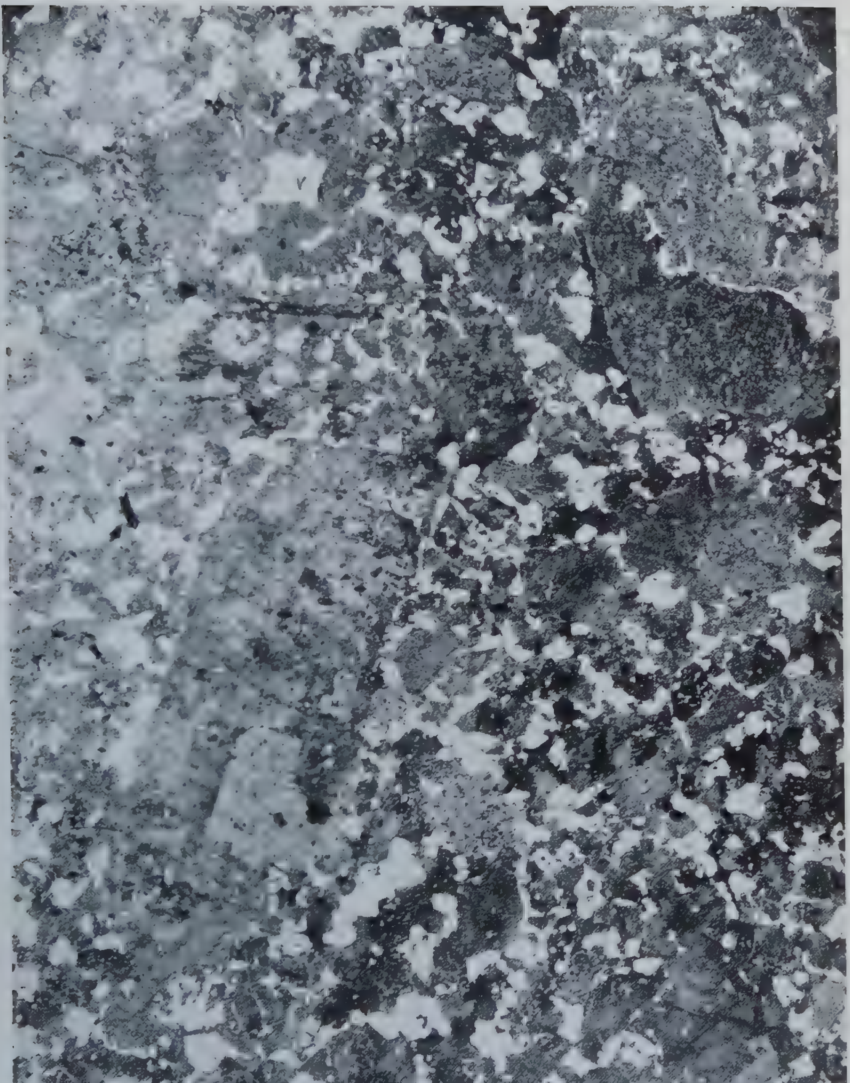
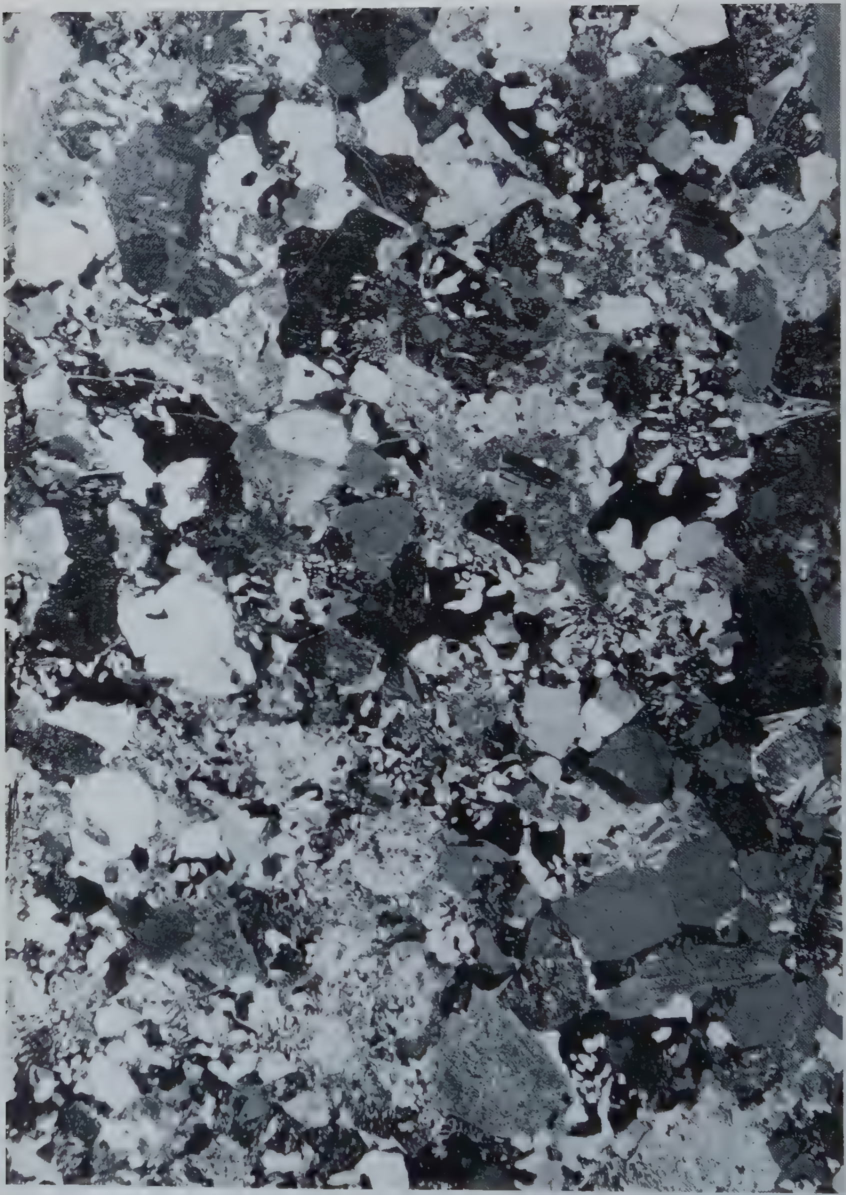


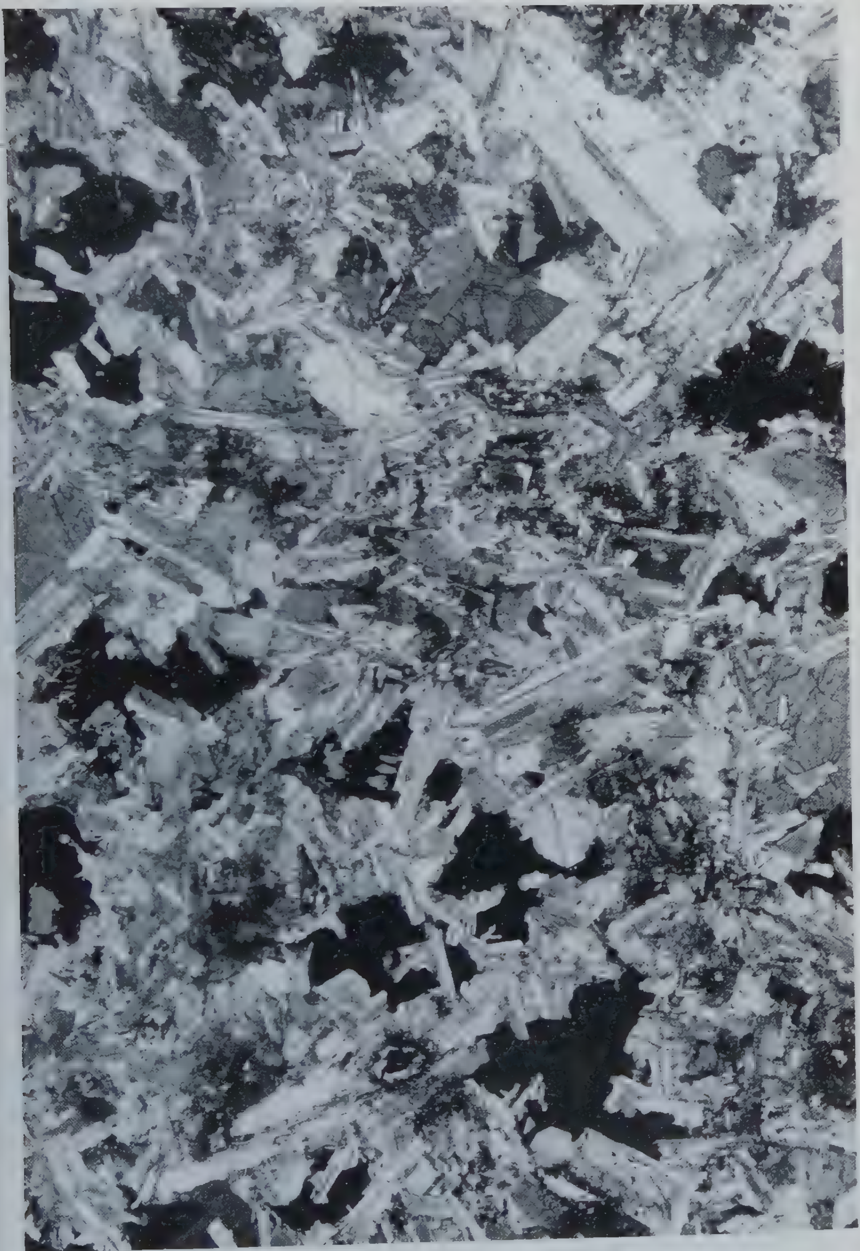
Fig. 2. Aplitic Rapakivi granite from Långtjärn. Nic. +. Magnif. × 10.



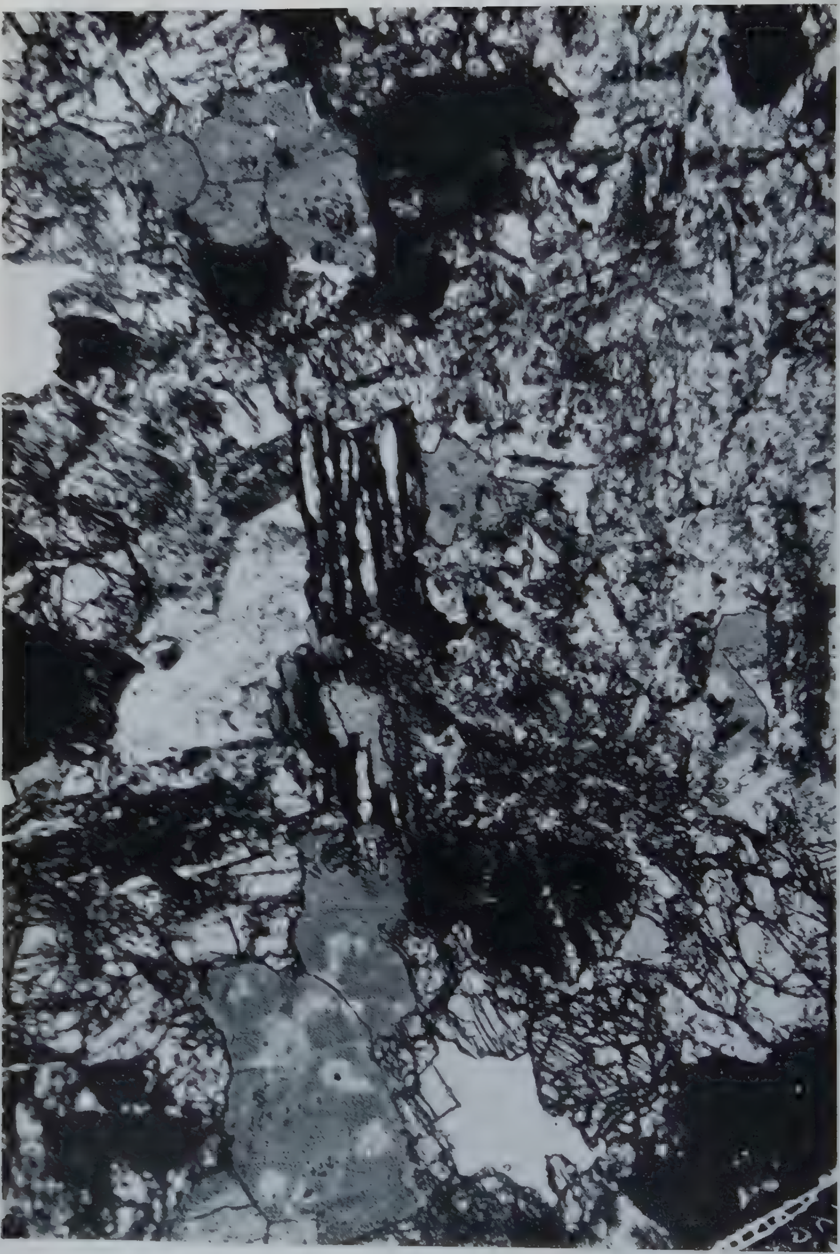
Rapakivi granite at point 402, Loberget. Ord. light. Magnif. × 10.



Rapakivi granite from road to Loberget Cottage. To the lower right, idiomorphic quartz grains. Nic. +. Magnif. × 10.



Coarse-grained doleritic diabase south of the Emådalen Bridge. Dark areas are clino-pyroxene. Gray mineral in upper centre is olivine. Texture ophitic. Nic. +. Magnif. × 10.



[illegible] doleritic diabase from Vassjöån. In the centre, uniaxial green pigeonite partly altered into chloritic substance. At the bottom to the right and left, red titaniferous augite. Large gray areas represent pseudomorphs of olivine. Ord. light. Magnif. × 40.

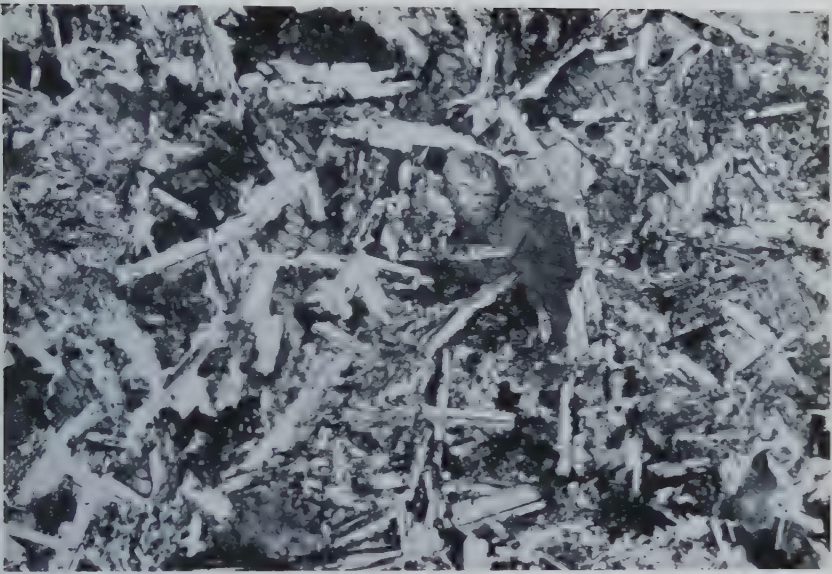


Fig. 1. Doleritic diabase from Helvetesfallet. Upper centre, and to the right, two corroded olivine crystals (light, gray). Dark-grey represents pigeonitic titaniumaugite. Ord. light. Magnif. × 10.

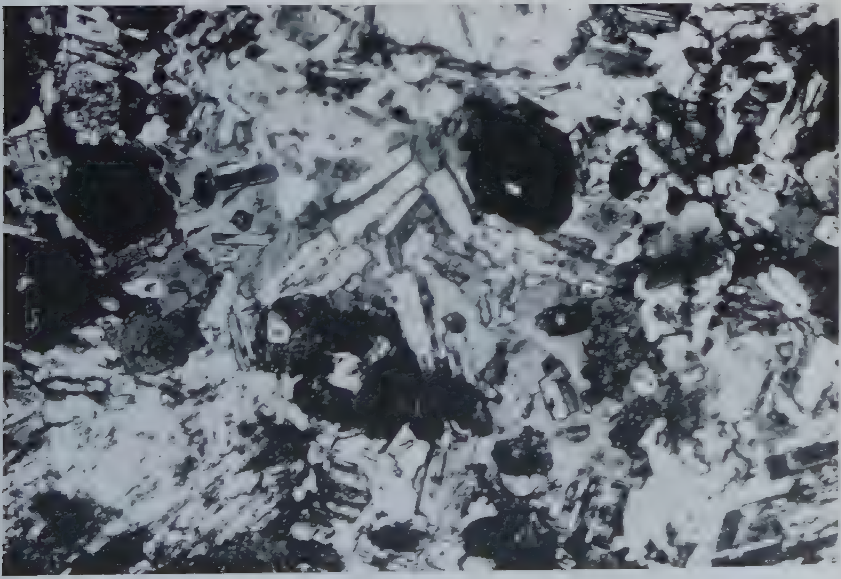


Fig. 2. Alkaline diabase from Keskinenmäki, south of Noppikoski. Black crystals are olivine-pseudomorphs. In the centre, white plagioclase laths within a gray anorthoclasic orthoclase base. Nic. +. Magnif. × 40.

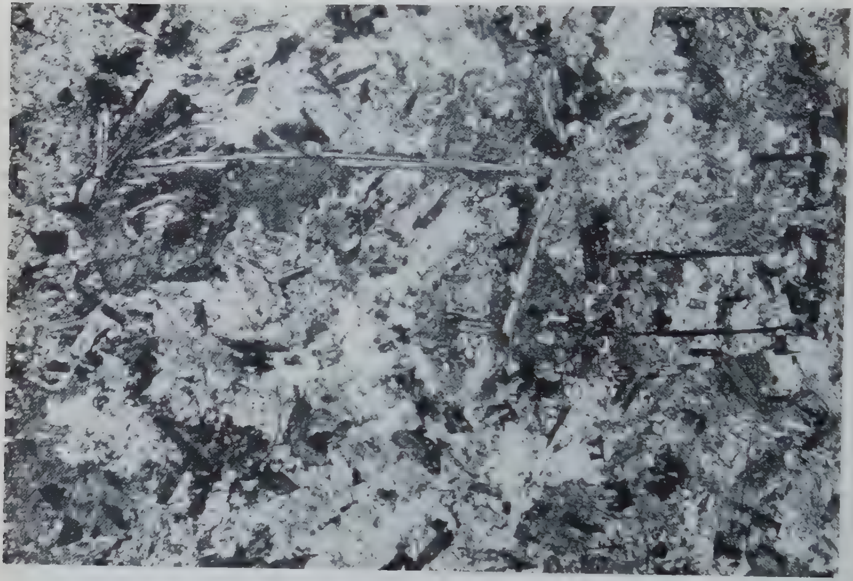


Fig. 1. Monzonitic doleritic diabase from Helvetesfallet. Upper centre, elongated pyroxenes. To the right, dark iron-one rods. Nic. +. Magnif. × 10.

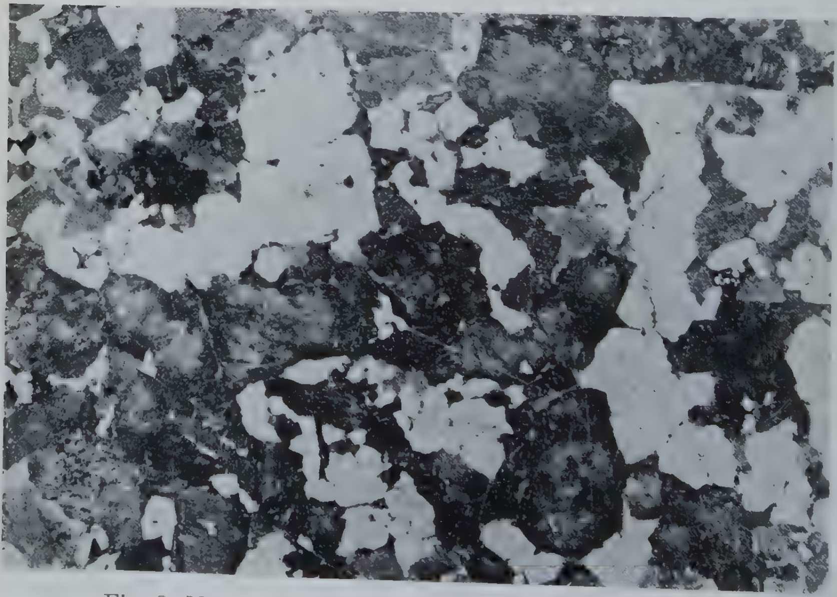


Fig. 2. Monzonite at Emådalen. Ord. light. Magnif. × 10.

secting, as a vertical fissure dyke in a northerly direction, the Bredvad porphyry and Garberg granite for a traceable length of more than 40 km. No petrographic details were given, however (cf. 22).

The field relations of the Loos-Hamra diabases are strikingly similar. Their maximum length surpasses even that of the »Åsen dyke», and their southern extensions at Helvetesfallet interfoliate the sandstone beds. To the earlier known tectonic emplacement of the doleritic diabases there has been added a new feature, however, resulting from the present mapping. A glance at the appended map will immediately show their occurrence as a rock, brecciating on a large scale, and also the unexpectedly large percentage of the jotnian area occupied by them.

From being at the outset considered as quantitatively unimportant members of the magma suite, they have, as the mapping proceeded, gradually been found to surpass even the masses of jotnian granite represented within the region, and if the intrusive sheets within the sandstones are taken into account and all hidden occurrences were known, their volume would be considerably larger than is pictured on the map.

In the preliminary report of the Loos area, attention was called to the previously unknown occurrence of two distinctly different ages of doleritic diabases, the older represented by fragments within the inter-jotnian tuffitic sediments, and brecciated by the green porphyrites of the later jotnian extrusion, while the younger brecciates the porphyrite, too. By Törnebohm the presence of two distinctly separated eruption periods was already assigned to the diabases of the late jotnian sandstones, one earlier, effusive, represented by Öje diabase on top of the lower part of the sandstone, and one later, intrusive, represented by the Åsby diabase interbedding the subsequent sedimentation deposited on the top of the former diabase. A definite period must have elapsed between the two, as the weathering out of the amygdales of the Öje diabase has produced the well-known agate conglomerates of the upper sandstone.

No evidence is obtainable within the present area to answer the question whether the hiatus marked by the erosion of the Öje diabase corresponds to the conglomeratic inter-jotnian sedimentation of the Hamra area, or if we may have to reckon with three subdivisions of the jotnian and, consequently, with three different periods of diabasic eruptions. The Öje diabase being of somewhat different mineralogical and, probably, of varying chemical composition, too, this latter theory may seem possible, but, on the other hand, a closer study of this rock may possibly disclose that the discrepancies are solely due to the normal development of the differenatiation within an effusive phase. As a tentative hypothesis, however, the writer has assumed a three-fold division of the diabasic eruptions, when computing the chronological diagram given in Fig. 3, p. 155.

To the magma-suite of the later Åsby diabases there may, in any case, be referred the monzonite which cuts the porphyrite, as well as the diabase interfoliating the sandstone at Helvetesfallet, both fully described in the following chapter.

In the author's preliminary report, the latest Åsby diabases, capping the youngest Jotnian sandstones of Dalecarlia were assigned to a post-Jotnian age, thus adhering to the opinion obtaining among Scandinavian petrologists ever since TÖRNEBOHM'S and HÖGBOM'S classification of the Öje diabase as Jotnian, and of the later diabases as post-Jotnian believed to have erupted at the close of the great Jotnian sedimentation period.

In the present paper, however, no mention is made of any post-Jotnian diabases, as in the writer's opinion they are all Jotnian. The reasons for his deserting his old point of view are given in full in the following chapter.

When mapping out the diabases, however, the author has not been able to distinguish the younger rocks from the older ones, as no reliable difference in textural, chemical or mineralogical properties has been discovered which allows of sufficient grounds for such a division. The field evidence, again, is far too insufficient, probably due to the easy weathering of the diabases, leading to their contacts being extensively covered by drift and talus.

One locality may be mentioned, however, as it caused a lively discussion last year, when two of my colleagues paid a visit to the field.

N.W. of Emådalen, on the northern bank of the Ämån river, big inclusions of fine-grained diabase are found within a green porphyrite. They resemble fragments of a thin sheet of diabase, brecciated by the porphyrite (cf. Pl. XCVIII, Fig. 2).

The suggestion was made, that they were parts of the chilled contact of a doleritic diabase occurring some hundred metres upstream, broken loose and embedded in the porphyrite as a result of the activation of the wall rocks.

At Älvho railroad bridge, where a large mass of diabase intrudes into the porphyries, such an activation is observable on a small scale, — minute strings of porphyry entering the diabase to a depth of a few inches at the contact. In the case of Ämån, however, the supposed remelting would be in inverse proportion to the amount of intruding magma, which does not seem reasonable.

Analysis Nr. 104.

Doleritic Diabase, Stensjöberg Hill (Ls - 137).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	46.00	76.59	Or . .	5.54	Plagioclase . .	47.8	qz	— 25	s	50.5
TiO_2	2.40	3.00	Ab . .	19.42	$(Ab_{40}An_{60})$		si	99	A	3.0
P_2O_5	0.35	0.25	An . .	28.92	Pyroxene . .	27.7	ti	3.87	C	6.6
Al_2O_3	15.39	15.10	Σ sal .	53.88	Olivine . . .	9.2	al	19.5	F	30.1
Fe_2O_3	2.44	1.53	Di . .	11.67	Biotite . . .	7.1	fm	53.0	a	2.5
FeO	12.78	17.79	Hy . .	7.08	Ores	7.3	c	21.5	c	5.0
MnO	0.01	0.01	Ol . .	18.42	Apatite . . .	0.9	alk	6.0	f	22.5
MgO	8.18	20.29	Mt . .	3.52		100.0	mg	0.49	n	8.0
CaO	9.23	16.46	Ilm .	4.56			k	0.21	k	0.82
Na_2O	2.32	3.74	Ap . .	0.91			c/fm	0.40		
K_2O	0.91	0.97	Σ fem	46.16						
$H_2O^{+105°}$	0.27	1.50	H_2O .	0.27						
				100.31						
$H_2O^{-105°}$	0.10									
	100.38									

Quantitative System: III: 5: 4: 4 — *Auvergnose.*
Osann's Type: No. 93. Krastorp (s 51, a 2.5, c 5.5, f 22, n 7.5. k 0.84)
Or: Ab: An — 10.28: 36.04: 53.68.
Sp. gravity $\frac{20°}{4°}$ C: 3.042

Analysis Nr 105.

Doleretic Diabase, from the S. E. slope of Acksjöberget Hill (Ls - 511).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	47.20	78.59	Or . .	9.49	Plagioclase . .	43.3	qz	— 22	s	54
TiO_2	2.70	4.23	Ab . .	22.23	$(Ab_{50}An_{50})$		si	112	A	3.9
P_2O_3	0.35	0.25	An . .	26.14	Pyroxene . .	29.2	ti	6.0	C	6.1
Al_2O_3	15.68	15.38	Σ sal .	58.16	Amphibole . . Chlorite . . . Serpentine . .	10.1	al	22.0	F	25.7
Fe_2O_3	3.51	2.20	Di . .	14.20			fm	46.0	a	3.5
FeO	10.77	14.99	Hy . .	8.50			c	23.5	c	5.0
MnO	0.18	0.25	Ol . .	6.51	Orthoclase . .	6.1	alk	8.5	f	21.5
MgO	5.09	12.62	Mt . .	5.09	Ores	8.0	mg	0.39	n	7.2
CaO	9.33	16.64	Ilm .	5.72	Quartz . . .	2.4	k	0.28	k	0.88
Na_2O	2.65	4.28	Ap . .	0.91	Apatite . . .	0.9	c/fm	0.51		
K_2O	1.63	1.73	Σ fem	40.93		100.0				
$H_2O^{+105°}$	0.70	3.89	H_2O .	0.70						
				99.79						
$H_2O^{-105°}$	0.15									
	99.94									

Quantitative System: III: 4: 3: 4 *Vaalose.*
Osann's Type: No. 92. Kinnekulle (s 53.5, a 3.5, c 5.5, f 21, n 8.0, k. 0.86)
Or: Ab: An — 16.32: 38.74: 44.94.
Sp. gravity $\frac{20°}{4°}$ C: 2.968.

Analysis Nr. 106.

Doleritic Diabase, eastern shore of Ämån River, south of Helvetesfallet (Ls - v - 562).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	48.65	81.00	Q . . 2.88	Plagioclase . 47.1	qz — 10	s 55.7
TiO_2	2.44	3.05	Or . . 6.13	$(Ab_{43}An_{57})$	si 120	A 3.4
P_2O_5	0.43	0.30	Ab . . 21.47	Pyroxene . . 22.5	ti 4.60	C 5.6
Al_2O_3	14.02	13.75	An . . 23.64	Talk, Chorite, Amphibole . } 14.2	al 20.5	F 26.1
Fe_2O_3	3.85	2.41	Σ sal . 54.12		fm 51.0	a 3.0
FeO	10.90	15.17	Di . . 9.39	Ores 9.1	c 20.5	c 5.0
MnO	0.19	0.27	Hy . 22.54	Quartz . . . 4.1	alk 8.0	f 22.0
MgO	5.62	13.94	Mt . . 5.58	Orthoclase . . 1.7	mg 0.41	n 7.9
CaO	7.62	13.59	Ilm . 4.67	Apatite . . . 1.0	k 0.21	k 0.97
Na_2O	2.51	4.05	Pr . . 0.28	100.0	c/fm 0.40	
K_2O	1.04	1.10	Ap . . 0.99			
$H_2O^{+105°}$	2.11	11.71	Σ fem 43.43			
S	0.14	0.44	H_2O . 2.11			
			99.66			
	99.52	Quantitative System: III: 5: 3: 4 — *Camptonose.*				
		Osann's Type: No. 92. Kinnekulle (s 53.5, a 3.5, c 5.5, f 21.0, n 8.0, k 0.86)				
— 0=S	0.07					
$H_2O^{-105°}$	0.25	Or: Ab: An — 14.03: 35.58: 39.86.				
	99.70	Sp. gravity $\frac{20°}{4°}$ C: 2.918.				

As the locality is important as evidence of the occurrence of diabase of older age than the porphyrite, it was made the subject of a detailed study.

Thin sections were prepared of the diabase inclusions at right angles to the surfaces of the supposed sheet. They showed a diminishing size of grain towards both surfaces and a coarser grain in the middle. Consequently, the fragments are not parts of the chilled surface of a larger dyke, but were originally cast as a sheet in a »mould» formed by older beds, between which the diabase has intruded. It is suggested that this »mould» may have been inter-Jotnian sediments.

The porphyrite was further studied in thin sections close to the inclusious and also at some distance. It proved in both cases to be a normal micropoikilitic felsitic porphyrite, — the base showing no signs of thermal metamorphism. Reference has previously been made to the »milky-way» texture of the porphyries bordering on the diabase at Älvho (cf. p. 280, 289). No such secondary alteration of texture was found in this case, which the author, consequently, believes to be a true case of primary brecciation.

Three analyses, Nos. 104—106, of the normal doleritic diabase have been made, the first two representing dykes, probably feeding channels, or larger extrusions exposed within the old gneiss granite and Rätan granite areas respectively, the last one being that of the interbedding diabase at Helvetesfallet, to which reference has previously been made.

Megascopically, the three rocks are of a very uniform aspect, while microscopically, as shown by the mode, the primary olivine of the two latter is completely altered into talc, amphibole, chlorite and serpentine. Increasing amounts of orthoclase and quartz, too, accompany the increasing acidity of the rocks. In every instance the texture is a well-developed ophitic one, the main primary constituents being plagioclase, a pigeonitic titanium-augite and olivine, and the accessories orthorombic pyroxene, alkalic felspar, biotite, titaniferous ores and apatite.

The composition is, undoubtedly, doleritic and the rocks should correctly be termed dolerites, — a nomenclature already employed by KROKSTRÖM in his papers on the corresponding rocks of Central Sweden. I prefer to compromise, however, the name »olivine-diabase» having been so extensively used in Swedish petrology for this very type of rock, that a sudden change might be more confusing than helpful. Consequently, I have classified them as doleritic diabases.

The plagioclase is generally quite fresh, markedly zonal, and twinned according to the albite, karlsbader, and pericline laws. Other types of twins are very rare. The zoning is sometimes retrogressive; for instance, N.W. of Emådalen, where the composition grades from An_{63} in the kernels through An_{75}, in the middle zone, to An_{61} in the margin. The usual range of composition within the crystals is about 5—8 %, but exceptions occur, such as in a sample from Helvetesfallet, where one large plagioclase crystal was found to be An_{65} in the core, while the marginal part was only An_{30} (cf. Pl. XCIII).

The average anortite-content undoubtedly increases southwards within the region, even if this is not clearly expressed by the analysed samples. 120 slides from different localities indicate an average value of 55 % An within the big dyke in the N., increasing to about 60 % at Stensjöberget, and reaching 70 % at Helvetesfallet. Simultaneously the maximum individual percentage reaches higher values such as 78—80 % at Helvetesfallet and Emådalen.

On the other hand, smaller dykes, wherever they occur, generally display lower basidity, such as at Keskinenmäki, S. of Noppikoski, where An_{63} is the normal value of the plagioclases of the centre of the dyke, while An_{45-50} prevails in its narrower extensions.

When present, the potassic felspar occupies the interstices either as an orthoclase or an anorthoclase, rarely showing any perthitic growth.

The titanium-augite is slightly pleochroic in a reddish brown colour, and the chemical composition must cover a fairly wide range, from almost clino-enstatitic-hyperstenic composition to augites rich in alumina. The following optic determinations fittingly illustrate this instability, which sometimes occurs within one and the same crystal:

Locality	$N_{\beta, 550}$	c/γ_{550}	$2V_{550}$	Character
Acksjöberget	1.685	32° 30′	44° 45′	augitic
Risberget	1.700	36°	43°	»
Stensjöberget	1.695	39°	55° 30′	»
Gensjöberget	1.715	37° 30′	48° 20′	» pigeonite
Keskinenmäki	1.695	35° 30′	32° 30′	pigeonitic augite
Emådalen	1.660—1.730	36—2°	5—60°	pigeonitic to hyperstene (42 % Fe_2O_3)
N.W. Emådalen	1.695	30—31°	35—40°	titanium-augite
»	1.660	25—27°	8—15°	clino-enstatitic pigeonite
S. »	1.700	27—30°	40—50°	titanium-augite
S.E. »	1.790	38°	50° 30′	augite
Helvetesfallet	1.665	27—30°	10—15°	clino-enstatitic pigeonite
»	1.680	29° 30′	39° 30′	titanium-augite
»	1.695	30°	39° 30′	» »
»	1.695	31°	41° 10′	» »
»	1.695	31°	40° 20′	» »

Very puzzling, to say the least of it, are the pyroxenes simply called »titanium-augites». Their optical character agrees neither with pigeonites nor with diopsidic augites, nor have they any correspondence in the dolerites described by KROKSTRÖM (19). They will be made the subject of a special study in a coming paper. The refractions given above are to be taken merely as approximative values, the determination having been carried out by the NIKITIN method on the universal stage.

The orthopyroxene is the somewhat older of the two pyroxenes and was more easily subjected to autometamorphic changes during the late magmatic stage of the congealing. It sometimes occurs in parallel intergrowth with the clinopyroxene. The colour is pleochroic, from a faintly greenish to a slightly reddish colour, and the axial angle varies somewhat, the average of ten determinations being $2V = 58° \pm 4°$, indicating according to WINCHELL a composition of 46 % $FeSiO_3$. KROKSTRÖM found the orthopyroxene of his rocks from the Brevendyke to occur in even greater abundance than the clinopyroxene, but in the present case the former pyroxene is, if it occurs, an almost accessory constituent.

The composition of the olivine varies within narrower limits, 74°—84°. At Helvetesfallet an optical angle of 77°30′ was determined, $n_{\beta\,550}$ being 1.740 ± 0.005, corresponding to about 42 % Fe_2SiO_4 · N.W. of Älvho, the diabase shows secondary reaction rims of an olivine poor in FeO, the original mineral having $2V = 78° 10'$ and the secondary mineral 86°, indicating a variation between 39 % and 25 % Fe_2SiO_4.

Occasionally, the olivine is wanting, the total absence of secondary decomposition products proclaiming the presence of an originally olivine-free phase of the diabase. This, for instance, is the case N.W. of Emådalen, where the rock grades, however, into the monzonitic types described below.

The alteration products of the olivine are generally grouped concentrically in the following order, counting from the centre of the pseudomorphs: (Iddingsite) talc — actinolitic amphibole — serpentine. In many cases these zones overlap, but whenever they are separated the same sequence reoccurs. The ores thrown out at the metamorphism are concentrated mostly at the previous outlines of the olivine crystals. Occasionally the actinolite is replaced by a green chlorite. The colourless or green serpentine forms narrow rims surrounding the metamorphs.

The biotite is rich in iron, and is of the high yellow-brownish colour which is the typical one in this type of rock. It is found to be crystallized mostly in close association with titano-magnetite adjoining, or even surrounding, the latter.

The quartz, when present, is symplectitically intergrown either with orthoclase occupying the last granophyric interstices of the rock texture or with plagioclase as narrow marginal rims. The ophitic texture and the mineral-constituents of the diabases are generally very uniform.

An exception, however, has been noted at Keskinenmäki, where two distinct generations of plagioclase occur, blurring the ophitic arrangement. The second generation, An_{35}, lies as small lathes within an anorthoclasic non-perthitic base. The titanium-augite is almost accessory, and the texture, consequently, sub-ophitic. A green pigeonitic augite occurs either independently as idiomorphic grains or surrounding the previously mentioned pyroxene. A fair amount of reddish-yellow biotite is conspicuous. The general impression of the texture is that of an anorthoclase-base (extinction $\perp\gamma/P = 9°$; $(010)/P = 10° 30'$), wherein all the other components float, so to say. The association between this light colour type of rock and the normal dark-gray diabase at Keskinenmäki seems to be one of gradual differentiation, no magmatic contact having been found. No analysis has been made, but there is hardly any doubt of the rock being unusually rich in alkalies, thus constituting a border case towards an alkaline differentiation (cf. Pl. XCV, Fig. 2).

The Albitic Type.

This alkaline character is still more emphasized in the equigranular greenish-gray dyke cutting the Noppi quartz-porphyries, about 500 m. W. of the Oreälv bridge. This dyke is undoubtedly of Jotnian age at least, as no traces of stress are observable within the texture. The dyke lies within the strike of the diabase at Keskinenmäki, and may constitute a connecting link with the diabase E. of Tallsjön. Its tectonical emplacement suggests, consequently, a close association with the doleritic diabases, while the chemical composition would have been puzzling but for the previously described alkaline differentiation of the Keskinenmäki dyke itself (cf. Pl. XCVII, Fig. 2).

Analyses Nos. 111 and 112 give the composition as well as the mode. The high alkali content compared with the low silica, »qz» being only »— 32», together with the nephelite in the norm, constitutes a strong alkaline feature. The lathe-shaped plagioclase is an almost pure albite set in a trachytic rather than in a diabasic texture. The pyroxene is colourless or slightly greenish, well-crystallized in small prisms, and of the following optic constants, corresponding to a pigeonitic diopside: $n_{\beta\,550} = 1.660 \pm 0.002$; $(\gamma - \alpha)_{550} = 0.024$; $c/\gamma = 37°$; $2V_{550} = 50°$. The anorthoclasic potassic felspar ($(010)/P = 8° 30'$) is seen in hand specimens as small red spots, the colour being derived from a pigmentation by iron-oxide. The mineral occupies, together with carbonate, the last solidified interstices of the rock. Occasionally, however, idiomorphic crystal-skeletons, of up to 1—2 cm. in diameter, are conspicuous on fractured rock surfaces. The green pleochroic chlorite seems to approach a delessitic composition. The carbonate within the pyroxenes is dolomitic and occurs, partly as a primary late magmatic mineral and partly as a secondary alteration product. The rock is of a clearly effusive character, as is emphasized by rounded vesicles filled by epidote, carbonate, prehnite and chlorite. The prehnite shows the following optic values: $\varrho < \nu$, $2V_{550} = 49° 30'$; $(\gamma - \alpha)_{550} = 0.021$; $n_{\beta 550} = 1.626$. Consequently, the optic angle is rather small.

This vesicular porphyritic diabase may be supposed to have filled the feeding channel of an extruded rest-differentiate, very rich in alkalis and carbonic acid. Its albitic character is comparable with the albitic pegmatites, described by Holmquist as a late differentiate of the olivine diabase of the island of Gubben, to which reference has already been made when discussing the andesinite-dykes of the Loos greenstone.

Analysis Nr. 107.

Monzonitic Doleritic Diabase, Vassjöån Brook (Ls - v - 209).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	49.47	82.37	Or . . 16.15	Plagioclase	qz −22	s 57.5
TiO_2	0.93	1.16	Ab . . 26.21	($Ab_{53}An_{47}$) . 49.6	si 126	A 5.4
P_2O_5	0.50	0.35	An . . 23.39	Pyroxene . . 20.5	ti 1.78	C 5.8
Al_2O_4	16.62	16.30	Σ sal . 65.75	Serpentine . . 14.7	al 25.0	F 19.8
Fe_2O_3	2.87	1.80	Di . . 8.89	Orthoclase . . 10.0	fm 42.0	a 5.5
FeO	6.15	8.56	Hy . . 4.44	Ores 2.9	c 21.0	c 5.5
MnO	0.18	0.25	Ol . . 9.74	Apatite . . . 1.2	alk 12.0	f 19.0
MgO	5.99	14.86	Mt . . 4.16	Titanite . . . 1.1	mg 0.55	n 4.2
CaO	7.67	13.64	Ilm . . 1.74	100.0	k 0.37	k 0.90
Na_2O	3.08	4.97	Pr . . 0.39		c/fm 0.50	
K_2O	2.73	2.90	Ap . . 1.24			
H_2O +110°	2.88	15.99	Σ fem . 30.60			
S	0.18	0.56	H_2O . . 2.88			
			99.23			

	99.25
− O = S	0.07
H_2O −110°	0.37
	99.55

Quantitative System: II: 5: 3: 4 — *Andose.*
Osann's Type: No. 57. Mte. Austida (s 59.5, a 5.5, c 4.0, f 20.5, n 6.9, k 0.94).

Or: Ab: An — 24.56: 39.86: 35.58.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C: 2.832.

Analysis Nr. 108.

Monzonitic Doleritic Diabase at the bottom of the Canyon of Ämå River, south of Älvho Station (Ls - v - 409).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's System	Osann's System
SiO_2	52.22	86.95	Or . . 13.89	Plagioclase	qz −10	s 56
TiO_2	0.77	0·96	Ab . . 23.04	($Ab_{56}An_{44}$) . 41.8	si 130	A 4.7
P_2O_5	0.15	0.11	An . . 18.63	Augite . . . 22.1	ti 1.50	C 4.0
Al_2O_3	13.82	13.56	Σsal . 55.56	Amphibole and	al 20.5	F 26.2
Fe_2O_3	2.13	1.33	Di . . 14.95	Serpentine . 17.3	fm 49.0	a 4.0
FeO	5.81	8.09	Hy . . 17.09	Orthoclase . . 13.8	c 20.5	c 3.5
MnO	0.17	0.24	Ol . . 4.31	Ores 4.6	alk 10.0	f 22.5
MgO	8.97	22.25	Mt . . 3.06	Apatite . . . 0.4	mg 0.67	n 6.8
CaO	7.66	13.66	Ilm . . 1.49	100.0	k 0.36	k 0.91
Na_2O	2.70	3.76	Ap . . 0.32		c/fm 0.41	
K_2O	2.33	2.87	Σfem . 41.22			
H_2O +105°	2.95	16.38	H_2O . 2.95			
			99.73			

H_2O −105°	0.40
	100.08

Quantitative System: III: 5: 3: 4 — *Camptonose.*
Osann's Type: No. 86. Ragon (s 55.5, a 3.5, c 4, f 20.5, n 6.2, k 0.80).

Or: Ab: An — 25.00: 41.47: 33.53.

Sp. gravity $\frac{20^\circ}{4^\circ}$ C = 2.834.

Analysis Nr. 109.

Monzonitic Doleritic Diabase from Lustjärnsberget Hill (Ls - s - 138).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's System		Osann's System	
SiO_2	53.12	88.45	Q	6.79	Plagioclase		qz	± 0	s	61
TiO_2	2.43	3.04	Or	16.73	$(A_{52}An_{48})$	39.1	si	152	A	4.9
P_2O_5	0.59	0.42	Ab	22.56	Pyroxene	23.4	ti	5.15	C	3.9
Al_2O_3	13.36	13.11	An	16.13	Orthoclase	16.7	al	22.5	F	21.1
Fe_2O_3	2.68	1.68	Σ sal	62.21	Amphibole	7.5	fm	45.0	a	5.0
FeO	10.98	15.28	Di	9.65	Ores	6.4	c	19.5	c	4.0
MnN	0.24	0.34	Hy	16.23	Quartz	5.5	alk	13.0	f	21.0
MgO	2.92	7.24	Mt	3.90	Apatite	1.4	mg	0.27	n	5.9
CaO	6.26	11.16	Ilm	4.59		100.0	k	0.41	k	1.05
Na_2O	2.68	4.32	Pr	0.54			c/fm	0.43		
K_2O	2.86	3.04	Ap	1.32						
$H_2O^{+105°}$	1.26		Σ fem	36.23						
S	0.25	0.78	H_2O	1.26						
				99.70						
	99.63									
— O = S	0.07									
$H_2O^{-105°}$	0.66									
	100.22									

Quantitative System: II: 5: 3: 3 — *Shoshonose.*
Osann's Type: No. 19. Konga (s 61, a 4, c 4.5, f 21.5, n 7.5, k 1.12).
Or: Ab: An — 30.19: 40.71: 29.10.
Sp. gravity $\frac{20°}{4°}$ C: 2.924.

Analysis Nr. 110.

Monzonite, from Emådalen at the bridge across Ämån River (Ls - v - 695).

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	57.34	95.47	Q	4.69	Plagioclase		qz	+ 4.5	s	65.5
TiO_2	1.35	1.69	Or	23.93	$(Ab_{73}An_{27})$	43.2	si	188.5	A	7.2
P_2O_5	0.26	0.18	Ab	33.04	Augite and		ti	3.36	C	2.2
Al_2O_3	14.21	13.94	An	9.18	Hornblende		al	27.5	F	15.4
Fe_2O_3	1.42	0.89	Σ sal	70.84	(Pseudomorphs		fm	37.0	a	8.5
FeO	10.15	14.13	Di	5.82	of augite)*	25.0	c	14.5	c	2.5
MnO	0.23	0.32	Hy	14.83	Orthoclase	22.0	alk	21.0	f	19.0
MgO	0.98	2.43	Wo	1.16	Ores	4.7	mg	0.13	n	5.99
CaO	4.15	7.40	Mt	2.07	Quartz	3.6	k	0.41	k	1.04
Na_2O	3.92	6.32	Ilm	2.57	Olivine	0.8	c/fm	0.40		
K_2O	4.05	4.30	Pr	0.11	Apatite	0.7				
$H_2O^{+105°}$	1.30	7.22	Ap	0.65		100.0				
S	0.04		Σ fem	23.21	* A few crystals of fayalite are also present in the rock.					
			H_2O	1.30						
				99.35						
	99.40									
— O = S	0.02									
$H_2O^{-105°}$	0.65									
	100.03									

Quantitative System: II: 5: 2: 3 — *Monzonose.*
Osann's Type: No. 38. Tabor (s 64.5, a 8.5, c 1.5, f 20, n 5.9, k 0.98).
Or: Ab: An — 36.17: 49.95: 13.88.
Sp. gravity $\frac{20°}{4°}$ C: 2.800.

Analysis Nr. 111.

Alkaline Dyke-Rock, W. of Noppikoski Waterfall (Ls - 811).

Analyst: N. Sahlbom.

	%	Mol. Prop. × 100	Norm	Mode %	Niggli's system	Osann's system
SiO_2	46.44	77.32	Or . . 15.59	Albite	qz −41	s 54
TiO_2	1.50	1.87	Ab . . 26.74	(Ab_{98}–Ab_{100}) 35.0	si 115	A 6.5
P_2O_5	0.78	0.55	An . . 17.50	Orthoclase . 15.5	ti 2.82	C 4.3
Al_2O_3	16.11	15.80	Ne . . 4.54	Diopsidic	al 23.5	F 23.8
Fe_2O_3	5.21	3.26	Σ sal . 64.37	Augite . . 17.9	fm 42.5	a 5.5
FeO	7.25	10.09	Di . . 8.55	Chlorite . . . 15.7	c 20.5	c 4
MnO	0.14	0.20	Ol . . 10.34	Ores* 10.3	alk 14.0	f 20.5
MgO	4.90	12.15	Mt . . 7.58	Apatite . . . 1.7	mg 0.42	n 7.1
CaO	7.72	13.76	Ilm . . 2.87	Epidote . . . 1.4	k 0.30	k 0.76
Na_2O	4.14	6.68	Cc . . 1.70	Dolomitic	c/fm 0.27	
K_2O	2.65	2.81	Pr . . 0.52	Carbonate . 1.4	c′ 11.5	
H_2O +105°	2.16	11.99	Ap . . 1.90	Pyrite . . . 0.6		
S	0.23	0.72	Σ fem . 33.46	Prehnite . . 0.5		
CO_2	0.74	1.68	H_2O . 2.16	100.0		
			99.99	* In parts of the rock the ores are replaced by titanite, the proportions being 10 % Titanite 90 % Ores		

	99.97	Quantitative System: II: 5: 3: 4 — *Andose.*
−O=S	0.06	Osann's Type: No. 86. Ragon (s 55.5, a 5.5, c 4, f 20.5, n 6.2, k 0.80).
H_2O −105°	0.36	
	100.27	Or: Ab: An: Ne — 24.22: 41.54: 27.19: 7.05. Sp. gravity $\frac{20°}{4°}$ C: 2.920.

The Monzonitic Type.

Together with the normal type of doleritic diabases, there occur monzonitic varieties connected with them by a gradual series of transitional rocks. The analyses Nos. 107, 108, 109, respectively, represent two different types of these monzonitic dolerites. The first, exposed at Vassjöån brook and in the canyons of Älvho, is of a more abyssal doleritic texture. The plagioclase ranges from An_{44}—An_{48} and is distinctly less zonal than that of diabasic rocks; the predominating pyroxene is an idiomorphic green pigeonitic augite of the following optic values: $c/\gamma = 25°—35°$; $2V_{550} = 48°—38°$. A fair percentage of diopsidic colourless pyroxene is also present, being mostly replaced, along the cleavages (110), by a brownish-gray chloritic fibrous substance. All the primary olivine is replaced by green serpentine and an actinolitic amphibole. The extinction of the orthoclase within the last crystallized parts of the rock is $(010)/P = 8°$; $\perp\gamma/(001) = 9°$, indicating

Analysis Nr. 112.

Alkaline Dyke-Rock, W. of Noppikoski Waterfall (Ls · 790)

Analyst: R. Blix.

	%	Mol. Prop. × 100	Norm		Mode %		Niggli's system		Osann's system	
SiO_2	46.67	77.71	Or . .	8.93	Albite		qz	−36	s	55.7
TiO_2	2.01	2.52	Ab . .	36.17	(Ab_{96} An_4)	39.4	si	118	A	6.2
P_2O_5	0.54	0.38	An . .	18.09	Orthoclase .	8.9	ti	3.32	C	4.5
Al_2O_3	15.67	15.37	Ne . .	1.06	Diopsidic		al	23.5	F	22.6
Fe_2O_3	5.24	3.28	Σ sal .	64.25	Augite . .	19.2	fm	42.0	a	5.5
FeO	7.28	10.13	Di . .	8.58	Chlorite . .	14.7	c	21.0	c	4.0
MnO	0.20	0.28	Ol . .	8.58	Ores	9.5	alk	13.5	f	20.5
MgO	4.21	10.44	Mt . .	7.61	Carbonate		mg	0.38	n	8.2
CaO	7.72	13.77	Ilm . .	3.80	(dolomitic)	2.5	k	0.18	k	0.81
Na_2O	4.51	7.28	Ce . .	2.43	Epidote . . .	1.5	c/fm	0.50		
K_2O	1.53	1.62	Ap . .	1.27	Prehnite . .	1.3				
$H_2O^{+105°}$	2.96	16.43	Pr . .	0.53	Apatite	1.2				
BaO	0.19	0.12	Σ fem .	32.80	Titanite . . .	1.0				
CO_2	1.01	2.30	H_2O .	2.96	Pyrite . . .	0.8				
S	0.24	0.75		99.91		100.0				
	99.59									
−O=S	0.06									
$H_2O^{-105°}$	0.30									
	99.89									

Quantitative System: II: 5: 3: 4 — *Andose.*
Osann's Type: No. 86. Ragon (s 55.5, a 5.5, c 4, f 20.5, n 6.2, k 0.80).

Or: Ab: An: Ne — 13.89: 56.29: 28.16: 1.66.

Sp. gravity $\frac{20°}{4°}$ C = 2.896.

an anorthoclasic composition. In hand specimens both rocks are of a dull greenish-gray colour and are fairly evenly medium-grained (cf. Pl. XCIV).

Of quite another appearance is the rock of the third analysis, No. 109, from Lustjärnsberg Hill. The long narrow needles of greenish black pyroxene are strikingly conspicuous and give the rock an ophitic character, which is non-existent microscopically. The texture is sub-ophitic only in parts, the ruling pyroxenes being quite idiomorphic, and free quartz making its entry as granophyric orthoclase intergrowths in the interstices.

The elongated twinned pyroxene-prisms, 10 × 0.2 mm. have crystallized before the felspars, even if they are sometimes bent almost into a semicircle by the stress arising during the final consolidization of the rock. A pigeonitic augite is indicated by $c/\gamma = 43°$ and $2V_{550} = 58° 10'$. The pyroxene is almost colourless, with a slightly reddish tint, and a dark green megascopic appearance derived from the green amphibole enveloping the needles and sometimes replacing them.

The rocks strongly remind one of the monzonites of N. Ulfö, described by SOBRAL (33); the hypersten cores of the elongated monoclinic pyroxenes, are wanting, however. While SOBRAL believes them to be contaminated rocks resulting from assimilation of granitic fragments by the diabase, the writer considers them in this case, to be normal members of the differentiation sequence of the doleritic magma, or, maybe, a hybrid rock originated at greater depths.

They occur within the Hamra region in several other localities besides those from which analyses have been made and they everywhere develop true to type, irrespective of the kind of country rocks they may have invaded. Generally, they are encountered as central parts of larger dykes, such as those N. of Lusbo, at Helvetesfallet, S.W. of Pilkalampinoppi and at the Gällsjö Lake (cf. Pl. XCV, Fig. 1, Pl. XCVI, Fig. 1). The mineral features in all those localities vary within even narrower limits than those of the diabase. The plagioclase, for instance, ranges from An_{40} to An_{60} and the pyroxene is as follows:

Locality	c/γ	$2V_{550}$	Character
Lusbo	43°	45°	Diopsidic augite
»	42° 30′	44—45°	» »
Gällsjön	38°	48° 20′	Augite
Rullbo	46°	45°	Diopsidic augite
Helvetesfallet	38—39°	41°	Pigeonitic augite

The gradual increase of orthoclase and silica, and the decrease of femic silicates accompanying an increasing acidity of the magma make a contamination genesis appear rather improbable (cf. Fig. 23). This normal development, observable everywhere in the field, leads in this case even to almost granitic segregations within the dykes

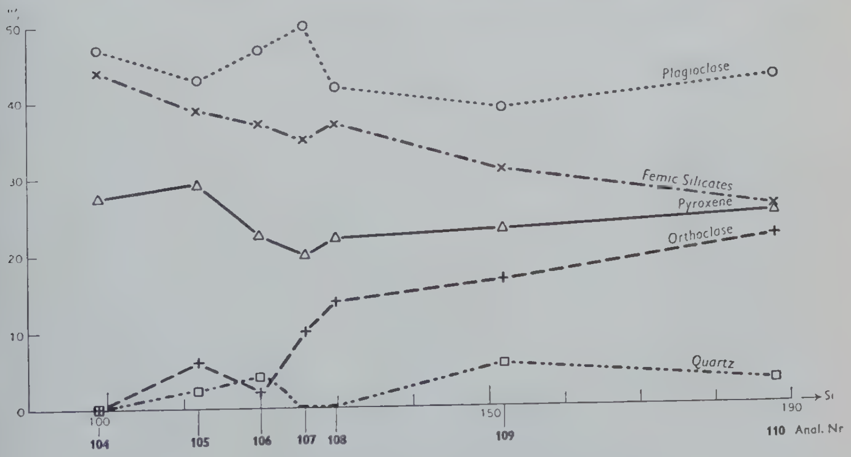


Fig. 23. Mineral composition of the monzonites.

themselves. This is exemplified at Pilkalampinoppi, where the central part of the dyke is a granophyric dolerite of almost the same character as that of a basic Rapakivi granite. Perthitic anorthoclasic felspar predominates and there occurs a brown basaltic hornblende besides a common green one, the extinction angles being: $c/\gamma = 0°—4°$ and $c/\gamma = 15°—16°$ respectively. This alkaline tendency governing the differentiation is a phenomenon worth noticing. On a minor scale it may also be traced at Helvetesfallet, where the enveloping green hornblende of the pyroxene needles is changed into a blue arfvedsonite when crossing the later crystallized plagioclase.

The differentiation at deeper levels of the doleritic magma also leads to still more acid monzonitic magmas ascending and intruding into the earlier congealed diabases. Such is the case at Emådalen, where a coarse-grained reddish-gray monzonite has cut through all the diabases as well as through the porphyries and porphyrites, displaying chilled marginal zones all along the contacts.

The analysis, No. 110, of this rock and the appended mode agree very nicely with an extended differentiation of the doleritic magma exemplified by the increase of potassic felspar and decrease of femic silicates. The texture of the rock is almost a granitic one, and the plagioclase a zonal oligoclase-andesine (An_{25} to An_{35}). The pyroxenes of the diabases — the reddish titanium-augite as well as the green diopsidic augite — are still present as relics, although most of the pyroxene has gone to form a green hornblende. Even perfectly fresh fayalitic olivine crystals occur occasionally and increase considerably in quantity towards the marginal area of the intrusion. The olivines are corroded but remarkably unaffected by the autogeneous late-magmatic metamorphism. Strictly speaking, the acid composition of the plagioclase and the presence of quartz do not agree with the true monzonitic composition, but constitute a rather strange border case of olivine-bearing quartz-monzonite (cf. Pl. XCVI, Fig. 2).

The differentiation of the doleritic diabase seems, however, to have been carried still farther and to have led to very acid part-magma's brecciating the diabase at Stensjöberget as leucocratic quartz-porphyry dykes. These dykes contain optically unhomogeneous quartz phenocrysts, within a microgranitic or granophyric base of optically homogeneous quartz and strongly FeO-pigmented orthoclase. The femic minerals are restricted to a few flakes of chlorite. An unusually large amount of accessory zircon is present, however.

In hand specimens as well as in thin section, this porphyry may easily be mistaken for an aplitic phase of the Rapakivi granite. Actually, there is no difference between this rock and the groundmass of a granite of the Sandsjö type. The optical strain of the quartz grains may be due to external stress on the congealing of the groundmass surrounding them.

On the other hand, however, one must not forget the existence of at least two generations of doleritic diabases and the possibility of the Stensjö dykes belonging to the older series, in which eventuality the later intrusion of the Rapakivi magma may be responsible for the brecciation. But even if this were so, the intimate connection between the acid Rapakivi and basic dolerite is rather striking, as the quartz porphyry dykes keep strictly within the boundaries of the diabase and do not wander into the surrounding gneiss granite. There is no getting away from the impression of their being either a late »Nachschub» or a later brecciating magma belonging to one and the same magmatic period.

The Relationship of the Rapakivi Granites to the Doleritic Diabases.

During his survey of the Loos-Hamra region, the author was, already at an early date, impressed by the Rapakivi-like differentiation of the diabase magma, and consequently suspected an actual consanguinity between the two. The close agreement between the differentiation of the effusive Dala-porphyry magmas and their plutonic counterpart, the Rapakivi, has already been shown (cf. Figs. 20, 22). In the Niggli diagram of the effusives has also been entered the analysis of the diabases. One will immediately notice the close correspondence of the trend of differentiation of the normal doleritic diabase with the continuing curves of the porphyrites of the Dala-series. The ultra basic porphyrites are also petrologically rather similar to the diabases, as pointed out in the preceding pages.

I conceive, therefore, the differentiation in the abyssel magma chambers to have led, consecutively, from doleritic diabases to porphyrites and porphyries. If, however, the diabasic magma has been extruded before it reaches the »porphyritic point», and in such large quantities as to retain the heat necessary for a secondary differentiation at higher level and at lower pressure, it will follow a different course of differentiation, marked by a break in the recording lines of »fm and al» at this point.

However, the trend of differentiation of »fm» and »al» following the break is the same as in the porphyries, »fm» only being higher, owing to an increase of magnesia, and the »al» lower, probably owing to loss in alkalies. The petrological development leads at the same time to increasingly acid monzonitic rocks of a definite alkaline character.

I have already called attention to the differentiation occurring in central areas within large dykes, approximately configural with the outline of the dykes.

The field and laboratory evidence substantiating this theory of the Rapakivi—doleritic diabase magma-province has been given in earlier chapters. The consequences of this new point of view, however, are of such a revolutionary character, affecting as they do the validity of the earlier, almost axiomatic, time-honoured conception of the sub-Jotnian unconformity, that I felt the need of looking for conformatory evidences elsewhere, too.

As the Rödö archipelago outside Sundsvall seemed to offer the greatest possibilities, easily accessible as the islands are to-day by motor-boat, some time has been spent there checking HOLMQUIST's admirable paper of 1899 on this district (13).

The archipelago consists of the big Rödön and smaller Röhällen islands, occupied to about 60—100 % respectively by a red Rapakivi granite intruding into old migmatites; of the doleritic diabase islands, Gubben and Draghällan, as well as of a dozen smaller islands of migmatite and gneiss-granite cut in all directions by porphyric and porphyritic dykes of the Rapakivi suite.

The Rapakivi has been analysed by N. SANTESSON (cf. 20, Anal. No. 56) and is somewhat more basic and sodic, but less alkaline than the analysis No. 94 from Oreälv in the present paper, the Niggli-reference values[1] and the mode (according to HOLMQUIST) being:

si = 406
qz = + 172
ti = 2.08
al = 45.5
fm = 16.5
c = 4.5
alk = 33.5
mg = 0.25
k = 0.40
c/fm = 0.25

Quartz	35.9 %
Orthoclase	19.5 »
Plagioclase ($Ab_{89}An_{11}$)	34.7 »
Biotite	4.0 »
Ores	2.4 »
Not accounted for	3.5 »
	100.0 %

On an average, however, it compares very well with the Oreälv Rapakivi, leaving no doubt as to the Rapakivi age of both granites. Unfortunately, only one analysis has been made of the basic dykes, and none of the diabase of Åsby type. The mineral description given by

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[1] Calculated by the author.

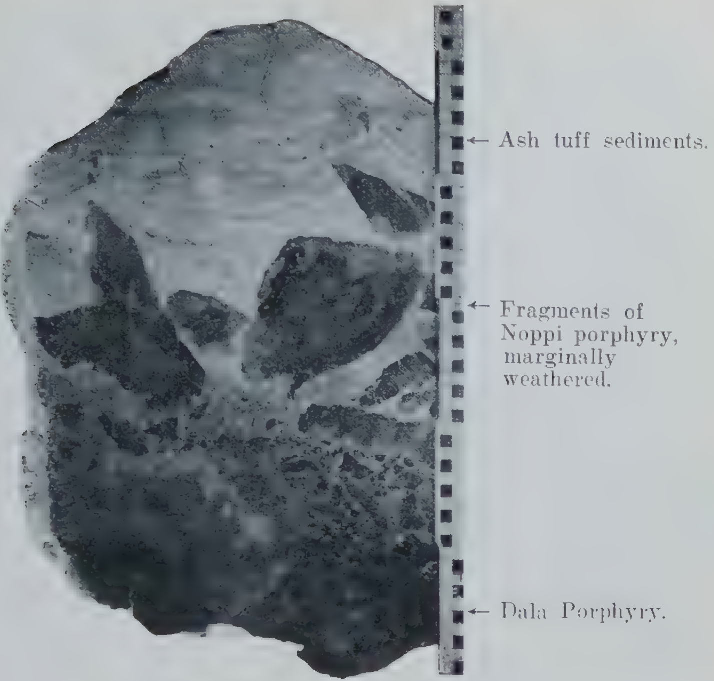


Fig. 1. Dala porphyry brecciating Noppi quartz-porphyry, south of Tallsjön.

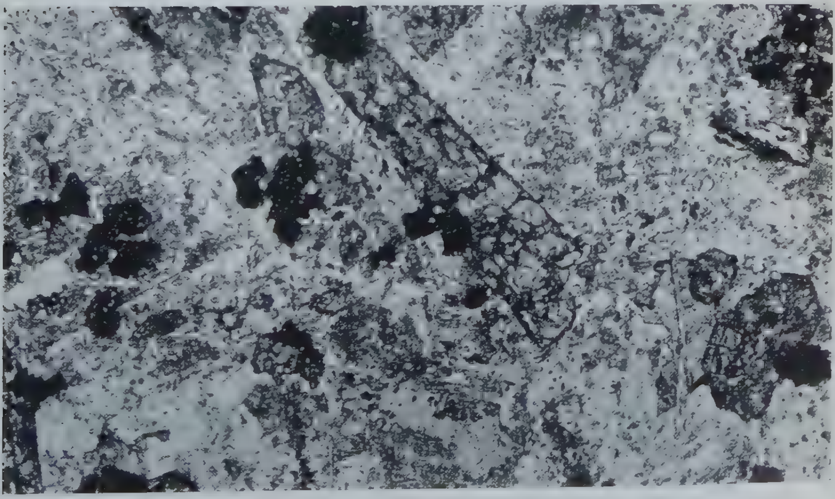


Fig. 2. Alkaline doleritic diabase dyke W of Noppikoski Bridge. The big phenocrysts are augite. Ord. light. Magnif. × 55.

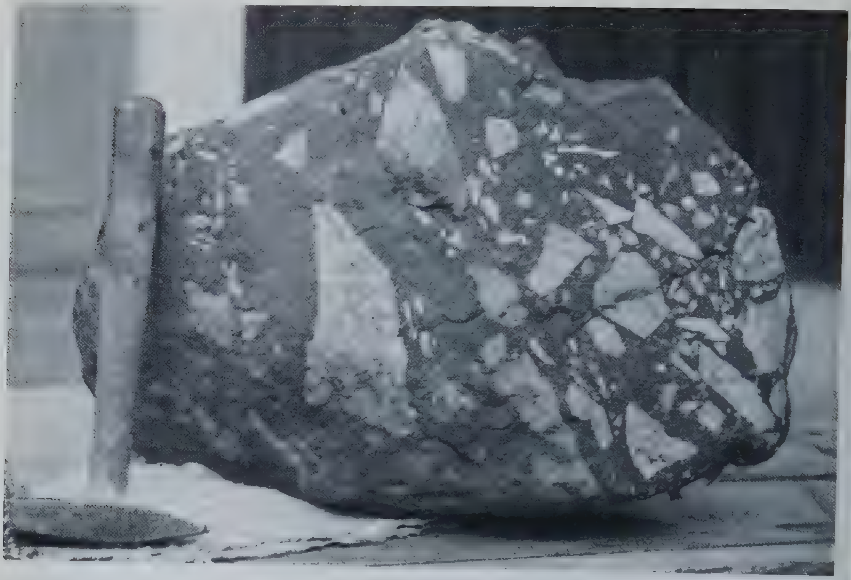


Fig. 1. Upper Loos quartzite brecciated by red Dala porphyry.

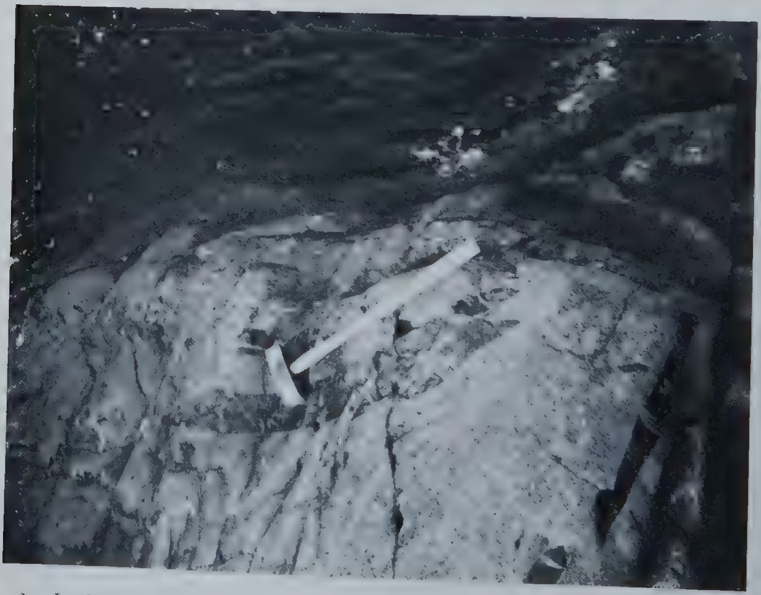


Fig. 2. Inclusions of doleritic diabase within green porphyrite at Ämån. The background is occupied by the river. A big fragment lies in the centre, another to the right.

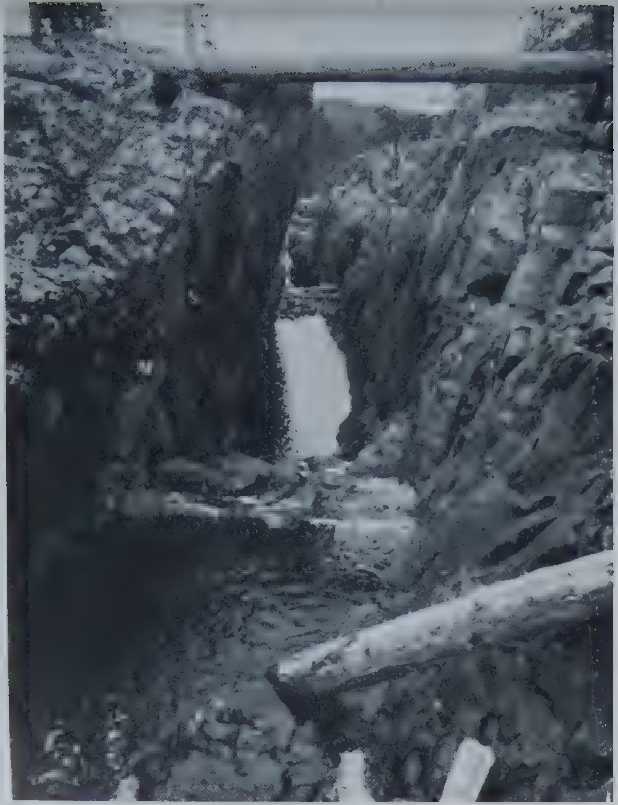


Fig. 1. The northern canyon, at Älvho. To the left, violet felsitic porphyry, at the bottom of the canyon monzonitic dolerite, to the right granophyre.

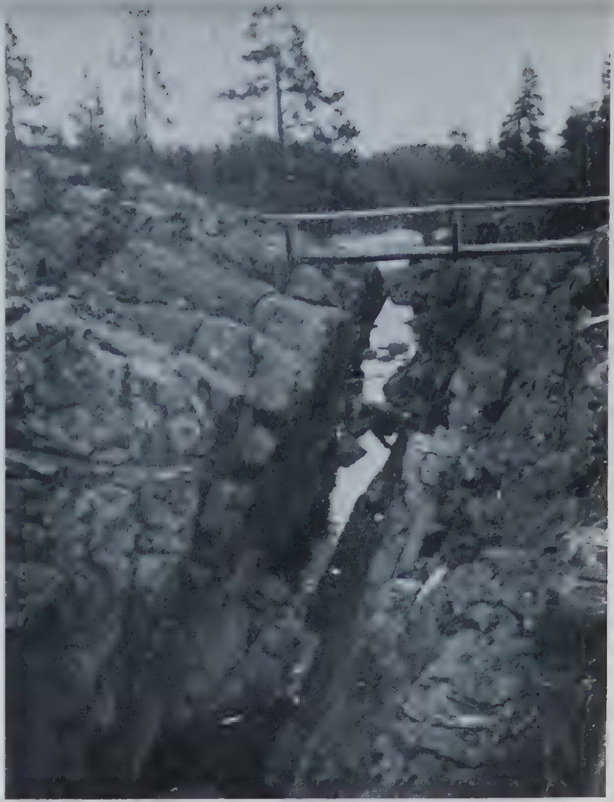


Fig. 2. The southern canyon, at Älvho. To the left, granophyre, at the bottom of the canyon monzonitic dolerite, to the right red porphyry.

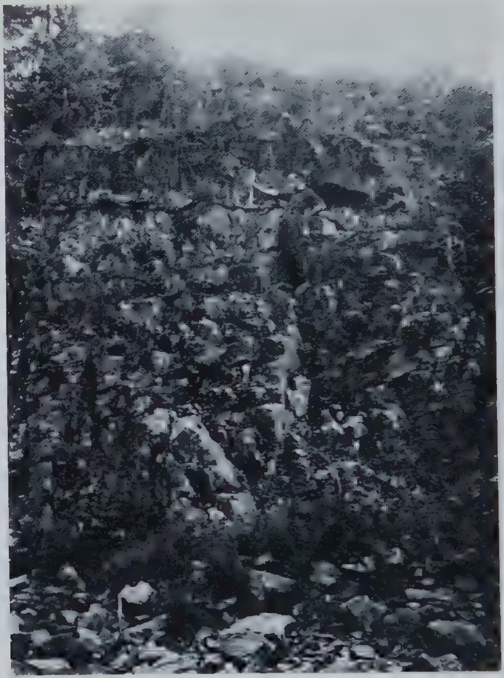


Fig. 1. Doleritic diabase intruded into jotnian sandstone south of Helvetesfallet. The lower contact runs at the head of the hammer. The upper contact of the diabase is not shown on the picture. The underbedding sandstones are gray, the overlying red.

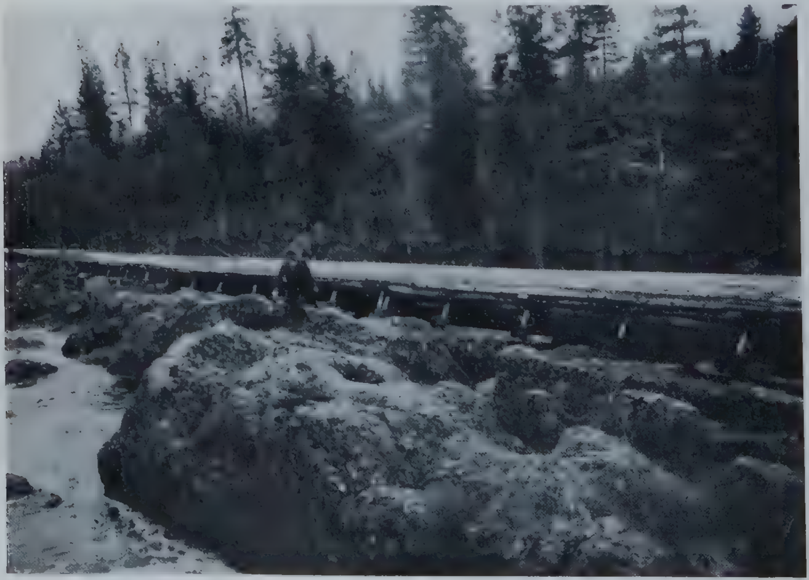


Fig. 2. Conglomerates of Bössfallet in the foreground. In the background on the other side of the wooden structure (timber-chute), overlying green porphyrite.

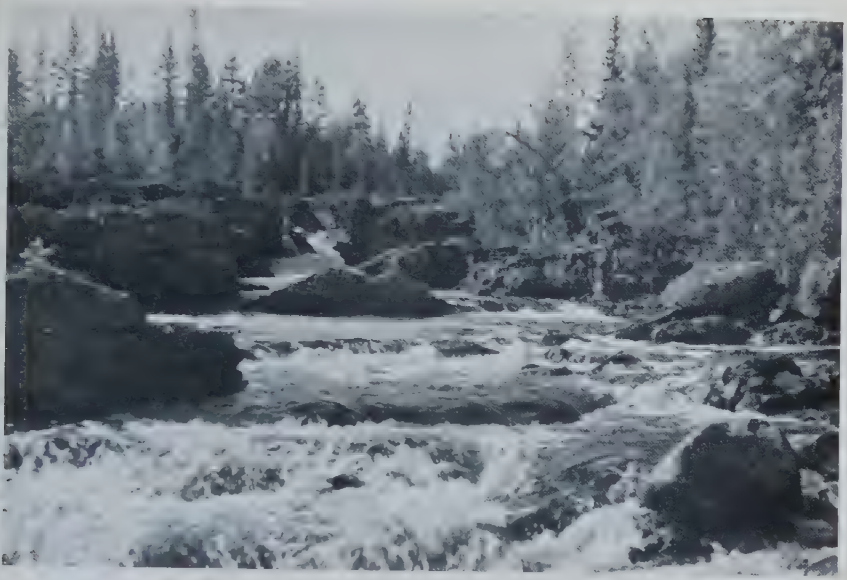


Fig. 1. The upper Bössfallet rapids. The rocks are all conglomerate.

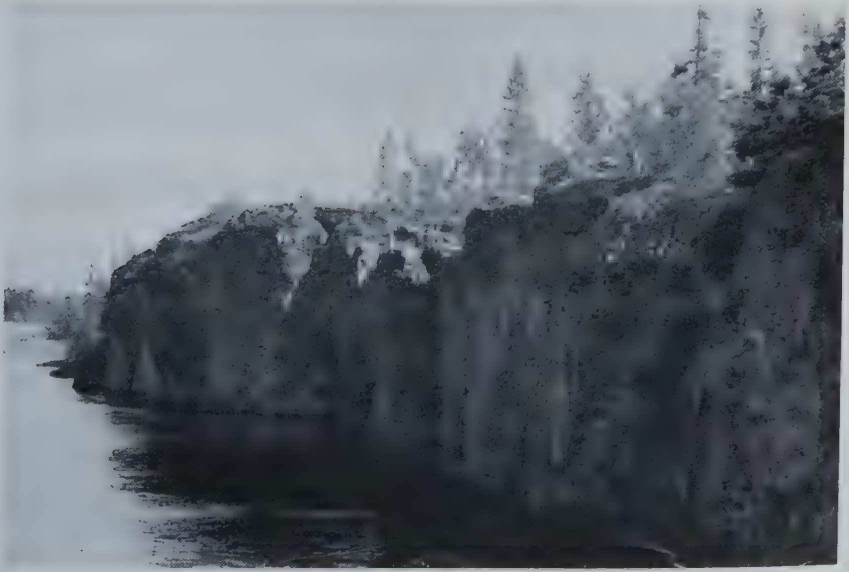


Fig. 2. At the foot of the upper Bössfallet looking SE. The cliffs are all conglomerate.

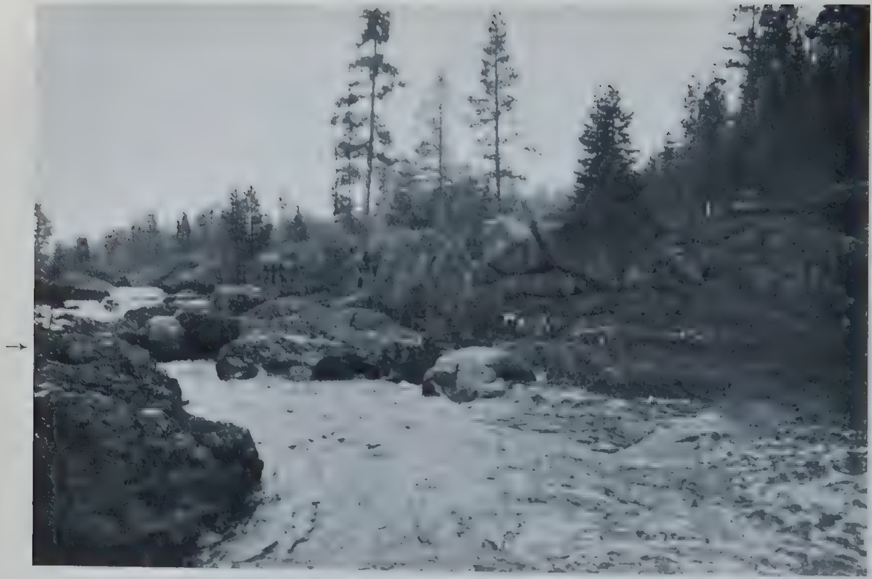


Fig. 1. The upper Bössfallet rapids. In the middle distance to the left a big boulder of Rätan granite within the conglomerate (arrow).

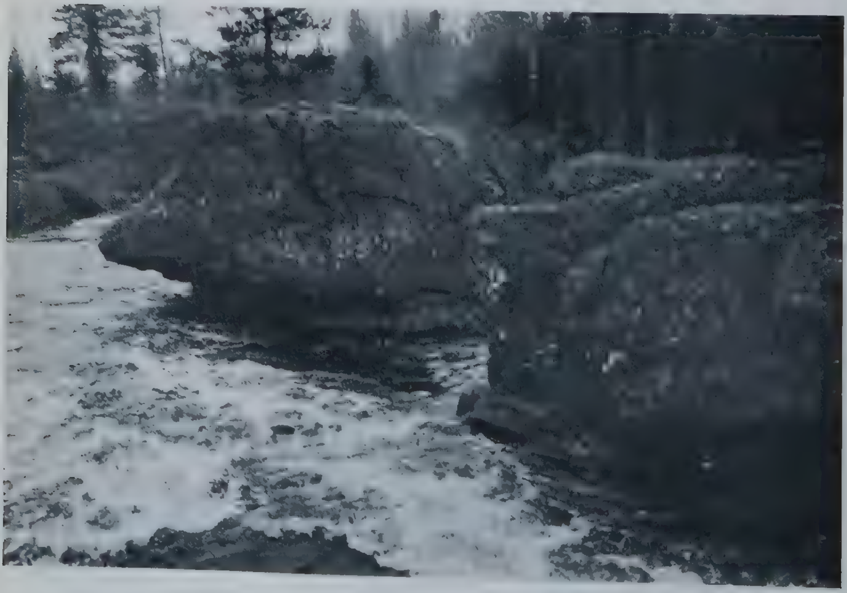


Fig. 2. Bössfallet rapids. In the foreground, beds of sandstone at the water-level, underbedding conglomerates.

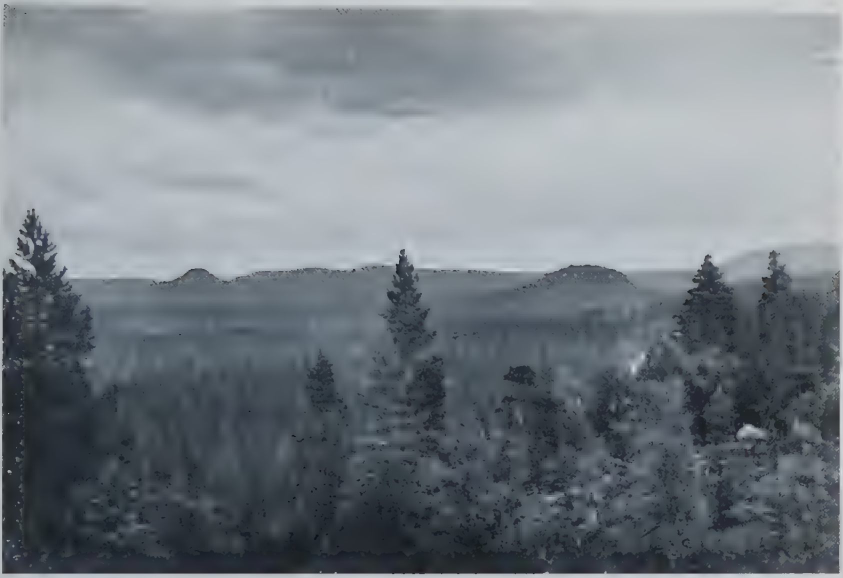


Fig. 1. View from St. Sillakorvamäki, looking east. The distant hillock is Noppimäki (Noppi quartz-porphyry). The hillock to the right is L. Sillakorvamäkti (Dala porphyry).

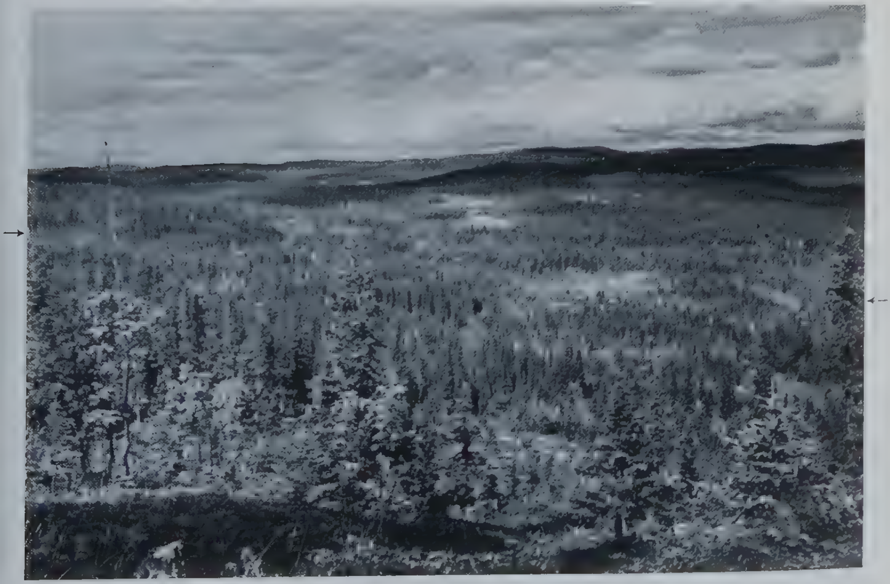


Fig. 2. View from Korpmäki (732 m above sea-level; Upper Noppi quartzite) towards the north. The distant hills are Dala porphyries. The dark ridge in the middle distance is Loberget (Rapakivi granite). The arrows indicate the strike of the diabase separating the uplifted quartzites of the foreground from the down-thrown porphyries and granite.

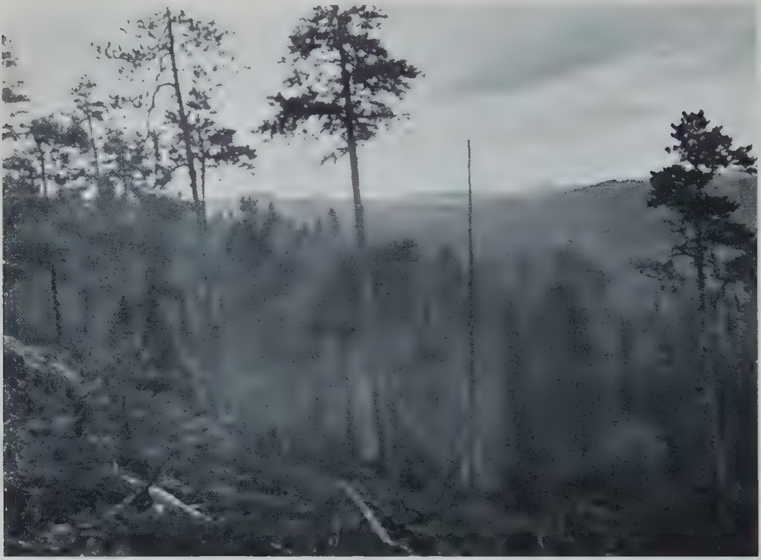


Fig. 1. View from Sillakorvamäki, looking north. The porphyry beds dipping towards the west are outlined against the horizon.

Fig. 2. The Author's cottage on the top of Tensberg Hill, the headquarters of the »Geological Survey of Loos» (L. G. U.).

Holmquist, as well as the examination of slides from samples collected by the author, show a close relationship to the corresponding Dalecarlian rocks.

Inclusions of a diabasic porphyrite within the acid dyke-rocks are numerous, as are also homogeneous basic dykes clearly intruded when the ground rocks were still regionally heated and the dykes, consequently, subjected to mineral alterations (uralitisation). The analysed dyke is of monzonitic composition, and a comparison with Analysis No. 110 of the Emådalen monzonite certainly suggests an analogous magmatic evolution.

	Gråfläsian Island Rödö. 19. Anal, XV.	Emådalen Anal. 110.
SiO_2	58.21	57.34
TiO_2	2.09	1.35
P_2O_5	0.32	0.26
Al_2O_3	15.54	14.21
Fe_2O_3	6.52	1.42
FeO	1.78	10.15
MnO	0.26	0.23
MgO	2.60	0.98
CaO	4.40	4.15
Na_2O	2.96	3.92
K_2O	2.58	4.05
CO_2	2.70	—
H_2O	0.56	1.30
	100.52	99.36
Plagioclase	$Ab_{66}An_{33}$	$Ab_{73}An_{27}$

An important discovery was made, however, at Rödön, a new dyke of unusual interest being found at the S.W. shore of the island, which dyke had evidently been overlooked by Holmquist. This vertical fissure dyke, about 6 m. in width, seems to have been a feeding channel, through which lava flowed during a considerable period, recording in successive layers of solified material on its walls the sequence of differentiation of the underlying magma chamber. It intrudes into the main Rapakivi area and is consequently younger than it. The first magma to erupt was a monzonitic diabase, gradually changing into a definite monzonite, which in turn grades into a true Rapakivi, almost identical with the surrounding wall-rock.

There is no question of a composite dyke, in the ordinary sense of the word, being intruded into a fissure torn open at different periods, nor of a differentiation within the dyke itself, but simply of the recording of a steady flow during a specified time.

The story told by the dyke can hardly be explained but in one way. The parental magma apparently differentiated into an acid top and a basic bottom portion, of which a major part of the acid magma first laccolithically (judging from the contacts towards the migmatites) intruded at higher levels. With the block displacements connected with the stresses set up by the emplacement of said magma as well as by the regional heating of the old rock ground, zones of weakness arose in the already congealed magma. Intermediary monzonitic differentiation members of the top part of the basic differentiate were forced through the resulting fissures, intruding at higher level or even reaching the surface, as verified by the amygdaloid fragments within the later dykes. This flow of basic magma continued until the still proceeding differentiation of parental magma gave birth to fresh concentrations of acid Rapakivi differentiates close to the ceiling of the magma chambers, which in their turn superseded the basic flow of the fissures and reached the surface as quartz porphyries.

This magmatic mechanism may, of course, have been repeated several times. Even if the dyke in question only records only one cycle, that single record is sufficient to establish the intimate relation and consanguinity between the Rapakivi and the diabasic monzonites. The extrusion of the fully differentiated basic rocks, the Åsby diabase, may be presumed to have occurred within this area at the last repetition of this cycle, when, consequently, the hot bottom part of the magma chamber was forced to the surface, or nearly so. The high temperature of the doleritic diabases is evidenced by the thermal metamorphism of the porphyries, to which reference has already been made, for instance at Älvho (cf. p. 270), and by the bed-intrusions over enormous areas into the Jotnian sediments. There is no evidence at present of two generations of doleritic diabases within the Rödö-district, but there is no theoretical bar to the cycles' having gradually affected increasingly deeper levels of the magma chamber, and, consequently, ejecting the diabases at several intervals.

Another important discovery was made at the island of Gubben. Reference has already been made to the albitic pegmatites of the W. shores of said island. On the E. shore, however, a most interesting differentiation within the diabase has remained unnoticed by previous investigators. Several big patchy areas occur of monzonitic rocks grading into acid red rocks of unmistakable Rapakivi character. They are not inclusions but clearly differentiations »in situ», in their turn locally brecciating the doleritic diabase. They are not dykes from afar but represent, to my mind, a local continuation of the differentiation process within such parts of the magma as were extruded before they had completely reached their basic equilibrium. The temperature and pressure, as well as the concentration of volatiles, being different from those ruling in the deep-seated magma chamber; the differentiation followed a somewhat different path to that of the abyssic rock, but the general trend of differentiation is certainly the same. Another very strong piece of evidence is, consequently, presented, proving the consanguinity and synchrony of the Rapakivi and the doleritic diabase.

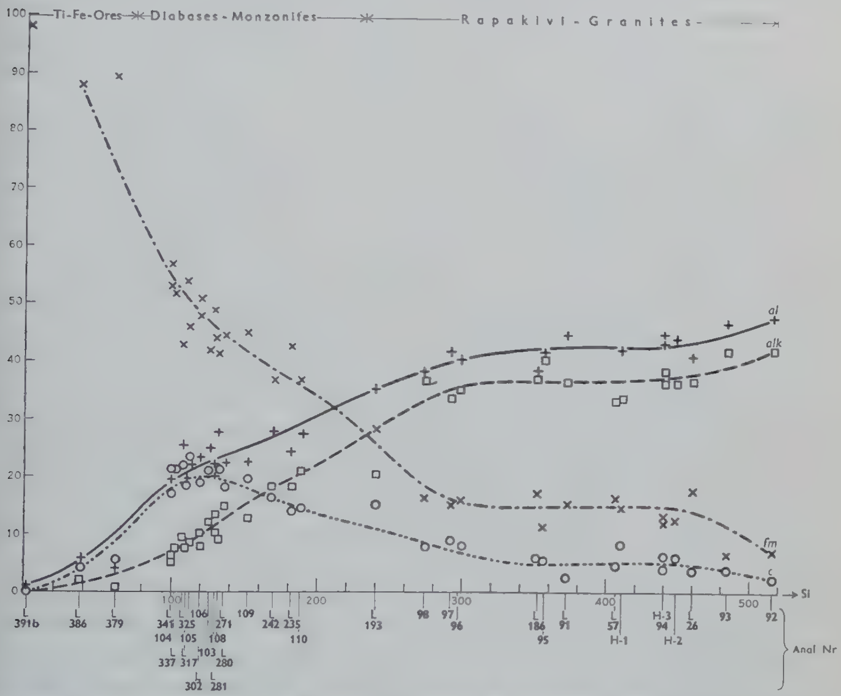


Fig. 24. Niggli diagram of Rapakivi Granites, Monzonites and Doleritic Diabases. ›L› refers to analyses recalculated by Larsson (20), ›H› refers to analyses published by Hackman (10).

In order to test my theory still further I have compiled all known previous analyses of Swedish doleritic diabases, including their most basic ore-differentiates, of Rapakivis and Rapakivic effusives as well as of a few Finnish analyses of corresponding rocks, lately published by Hackman, comparing them with the analyses of the present memoir and expressing them all in Niggli values. The result will be found in Fig. 24, where also the average differentiation curves are drawn. This diagram gives a comprehensive view of the development of the differentiation and suggests that the composition of the parental magma was located somewhere about $\mathrm{si}_{200-250}$. Actually, this space of the diagram is occupied by the analysis of the Venjan porphyrite of Dalecarlia, — a rock of somewhat doubtful position.

The reference values of this rock are actually, the only ones not in good agreement with the differentiation sequence, their »alk» being too low and the »c» too high. When referring the Venjan porphyrite to the combined Rätan-Dala-group, HÖGBOM was, from his point of view, on safe ground, as there is no question of its being related to either of them. TÖRNEBOHM, in his description appended to the geological map of Sweden of 1910, considered them to be related to the Dala porphyrites. Nothing is actually known about the field relation of the said rock, and the author has only had the opportunity of a few hours' visit to the district. His impression, however, is that they may just as well belong to the pre-Jotnian Rätan-group as to the Dala-group. Even if the reference values of the single existing analysis do not fit in very nicely with the variation diagram of the Rätan granites — the position of »alk» and »fem» being almost reversed at the same »si» — the correspondence is in any case somewhat better than with that of the Dala-group. The absence of any other abyssal or hypabyssal basic members of the Rätan sequence (except a very small occurrence at Viidamäki) is also significant. Consequently, all that can be said to-day is that the Venjan porphyrite apparently corresponds to the theoretical composition of a parental magma of both the Rätan and Rapakivi granites. It may belong to either of these groups, the evidential indications of to-day slightly favouring the former group.

In any case, this analysis does not seem to impair the validity of the differentiation diagram of the Rapakivi diabase magma suite. Of special interest is the agreement of the albitic pegmatite from Gubben (L-26, Fig. 24) with the normal variation of the differentiation of the series. Another interesting point is the »falling into line» of the ultrabasic differentiate, N. of the Rödö area, represented in the diagram by the few available analyses in SOBRAL's paper on the Ulvö islands.

When computing the Or : Ab : An ratios of the Dala effusives and the abyssal or hypabyssal Rapakivi-Monzonite-Diabase magmas, one is also impressed by the similarity of the two diagrams (cf. Fig. 25 and 26).

When advancing my new conception of the contemporaneous Rapakivi-Diabase province at lectures held previous to the publishing of this memoir, I have been met with several objections. One has been the incompatability of the large volumes of granitic liquid compared with the insignificant volume of basic liquid resulting from the suggested large-scale differentiation of the necessarily basic parental magma. To this may be answered, that the apparent difference in volume is largely misleading, owing partly to the intrusive beds of the diabase being covered by Jotnian sediment, and partly to their having been extruded on top of the sediments, and, consequently, removed earlier by erosion. The basic bottom portion of the magmatic differentiation chamber is also less easily forced to higher levels than the acid liquids are, and consequently may remain uncovered ta greater depths. As regards the Hamra-region, I have already called attention to the equal proportions of the two poles of differentiation. I firmly believe that a detailed survey of the total Dalecarlian Jotnian area will reveal additional, at present unknown, masses of doleritic diabases, which, when computed, will almost outweigh the Rapakivi.

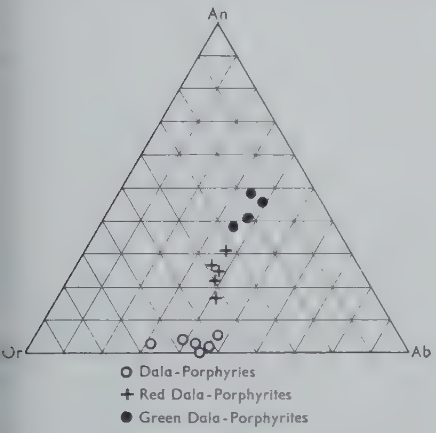


Fig. 25.

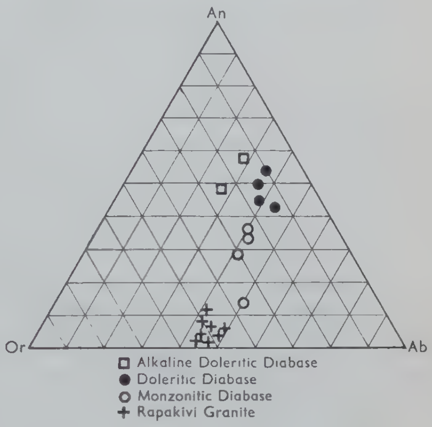


Fig. 26.

Turning to the Jotnian area at Gefle, the diabase is clearly the dominating eruptive rock, and bearing in mind the Ragunda-Nordingrå-Rödö-area, a mere glance at the new geological map of Sweden (1935) will show how the district is dotted with intruded diabases, which I am sure, if properly mapped would combine into larger areas equalling the Rapakivi. It is only E. of the Baltic that the Rapakivi masses clearly dominate, the diabases being confined to the Björneborg—Raumo-area and the islands of Lake Onega.

The other objections raised against my theory have so far all been connected with the »axiomatic» sub-Jotnian unconformity on top of the Rapakivis, and the improbability of a magmatic consanguinity between Rapakivi and diabase across this supposedly enormous hiatus.

The following chapter will dispose of these objections by establishing the sub-Jotnian unconformity at a position below the Dala-series.

The Sub-Jotnian Unconformity.

In his paper on Fenno-Scandia, when stating his own view — which was also that of his contemporaneous Swedish geologists — on the Jotnian unconformity, HÖGBOM apparently already »smelt a rat», even if he could not locate it.

After having described the sub-Jotnian erosion surface as a peneplane without projecting hills or sculptured valleys, covered by arkoses grading into the underlying rocks, he emphasized the necessary removal of thousands of metres of pre-Jotnian rocks. He especially pointed out the great sub-Jotnian erosion interval needed to expose the Rapakivis which, as he puts it, »are so considerably older than the Jotnian sandstones». To the following sub-Cambrian denudation he allotted an erosion restricted to the removal of the Jotnian sediments, wherever they were not protected by down-faulting. Where he felt uneasy, however, was when he had to discover a reason why this faulting is found in conspicuously many cases to be bound to the Rapakivi areas, and why those areas are in most cases accompanied by the Jotnian sandstone. He had to content himself with the statement that »a satisfactory reason is not easily found».

In the last edition of RAMSAY's textbook on geology, ASKLUND draws attention to the tectonic movements, following the intrusion of the »sub-Jotnian eruptives», as being in operation only during a limited time, during that period creating subsidence areas or »rifts», where the sandstones were deposited. The local down-faulting of the sedimental areas he seems to refer to the extrusion epoch of the »post-Jotnic» diabases, assuming a large part of the earlier Jotnian sediments to have been eroded away in the meantime.

SEDERHOLM, in his last paper on the geology of Fenno-Scandia (Fennia Vol. 55 No. 2, 1932), estimated the height of the Rapakivi laccoliths, congealed under cover of older rocks, at several thousand metres, and conceived their relevelling before the deposition of the Jotnian sandstones took place. He admitted the occurrence of two generations of diabases: the Jotnian olivine diabases intruding the sandstones, and the pre-Jotnian diabases, ossipites and labradorites being cut by the Rapakivis, although genetically connected. He also drew attention to the so-called »Digerberg sandstones» within the Dala porphyries, as well as to the sandstones of Petrosavodsk at lake Onega, partly filling »the immense gap between the Jatulian and the Jotnian», and assigns them, together with their associated eruptives, to a special Hoglandian series. The introduction of this series may have been a step in the right direction, but they did not furnish any answer to the Högbom question.

The conclusion to be drawn from the evidence presented in the present memoir, however, permits of such an answer. I am quite aware of the revolutionary character of those conclusions, as well as of the necessity of testing their validity by extended researches within the other Rapakivi areas, and especially within the remaining part of Dalecarlia. This memoir, nevertheless, would be incomplete if it did not point out the obvious deductions reached.

I may begin by emphasizing the strange coincidence that not only the Fenno-Scandian Rapakivis and sandstones, but also the doleritic diabases, always occur together. This undeniable fact has escaped the attention of Fenno-Scandian geologists, probably owing to the blinding effect of the axiomatic enormous sub-Jotnian unconformity, conceived by the leading authorities as separating the Jotnian sediments from the granite. This great hiatus certainly makes such a connection unthinkable, or they would long ago have given more thought to Högbom's still unanswered question.

One may well, for instance, have asked how a breaking down of thousands of metres of Rapakivi granites, as well as the thick cover of older rocks, was possible in a supposed extremely arid area, without a noticeable mountain folding having previously taken place. The question may well have presented itself, too, as to which strange »intra-telluric scent» helped the Jotnic, and still more the post-Jotnic diabases, following the enormous unconformity, to concentrate on the sandstones as well as on the Rapakivis, while avoiding all other areas. A third matter for consideration should have been the numerous vesicular fragments of surface rocks within the dykes of the Rödö Rapakivis, at a tectonic level thousands of metres below the surface, assumed by Sederholm. A fourth difficulty lies in the great Dalecarlian sandstone area not being bound by faults on its N.E. joint, as supposed by Törnebohm and Högbom, but tapering out over the underlying porphyries in almost undisturbed layers of horizontal bedding, — as shown by Olivecrona.

Ignoring the supposed post-Rapakivi unconformity and regarding the Rapakivi-diabase magmas and the sandstones as belonging to one and the same great magmatic province and evolution epoch, everything is presented in quite a different light.

To begin with, the difficulties attached to the old conception are removed. It stands to reason that the regionally geographic emplacement of the Rapakivis and diabases is one of necessity, their common history of magmatic evolution being amply supported by the evidence presented in this memoir. It also follows that the hiatus of the »Great Jotnian unconformity on top of the Rapakivis» must be more or less a myth, and must constitute merely an episode of a much larger geological period.

The main support for a sub-Jotnian peneplane on top of the Rapakivis has been sought in the fairly even base of surface-weathered labradorites and gabbros underlying the diabas-capped sandstones of the Nordingrå area. Moreover, Högbom also claims that Rapakivis are exposed in the arkose base, but the one locality, which occurs at Trysundaön, does not seem to be fully elucidated even if the Rapakivis, nevertheless, may be taken as older than the sandstones.

There is, consequently, nothing definite to be said regarding the weathering and levelling of the Rapakivis, as compared with that of anorthosites and gabbros. Actually, the Rapakivi granite rises to topographic levels surpassing the adjoining areas of the basic rocks by 100—150 m. The younger age of the Rapakivis is unquestionably established, and a common peneplane must presuppose a down-faulting of the older rocks. No faults, however, are observable at the northern contacts of the basic rocks adjoining the granites, the joint being typically magmatic, as is also clearly indicated on Sobral's map of the district.

Even if no chemical data are available to allow of a closer study of the subject a certain consanguinity is, nevertheless, apparent between the Rapakivi and the older basic rocks of the Nordingrå area, recalling the relations between the Dala series and the syenitic Rätan granite, which may or may not indicate an earlier pre-Jotnian levelling of the basic rockground. No sub-Jotnian peneplane above the Rapakivi, consequently, is proved to exist at Nordingrå.

Another proof of the existence of the sub-Jotnian unconformity, to which reference is sometimes made, is the undulating gneiss plateau of more or less uniform height in the tract between Cape Wrath and Laxford, on which the Torredonian succession of sandstone was laid down. Farther south along the Scottish west coast, however, the old land surface was carved into hills and valleys, and Peach and Horne definitely state the pre-Torredonian to be one of high relief, (cf. Chapters of the Geology of Scotland p. 72).

Turning to the Dala area, the supposed peneplane below the sandstone is far less substantiated, and is more due to imagination and lack of local familiarity with the region than actually observed facts. When taking into account the block-faulting of the arean, the topography seems to be more regulated by the naturally horizontal character of the lava flows than by any later erosion.

Wherever the contacts between the porphyries and overlying sediments are exposed for examination and are easily accessible, such as is the case along the shores of Ämån from the Helvetesfallet southwards, it is easily established that the erosion cannot have been a very deep one; distinctly vesicular and effusive green porphyritic dykes cutting the red porphyry, being still observable on the eroded surface.

The frequent presence of well-preserved fragments of brimstone lavas within the tuffitic bottom parts of the upper sandstone beds (cf. Pl. LXXXIV) also indicates a comparatively slight erosion of the volcanic ground prior to the sedimentation process.

The evidence within the Hamra—Orsa area is remarkably clear in this respect. Farther to the S.W., it is true, at the S.W. boundary of the great sandstone area round Malung, pure quartz-sandstones come into direct contact with the old archæan, which feature may be employed as an argument for an extensive erosion in this part having preceded the deposition of the sediments. For one thing, however, one must bear in mind the possibility of a transgression over areas never covered by the Dala eruptives, but in this case there is also no doubt of the contact being a purely secondary one, due to faulting. The sedimental beds are vertically uptilted along the fault, and the tuffitic sediments, as well as the porphyry, would hardly be expected to appear at the surface.

A comparatively slight erosion is not in any way incompatible with the exposure of the Rapakivi, which SEDERHOLM had already supposed intruded as laccolitic sheets which may even — as verified by the present memoir — almost have reached the surface, solidifying as granite in the lower parts and as granophyric porphyries in the higher parts of the flows.

The fact obviously overlooked when postulating the Rapakivi peneplane of Dalecarlia is that the horizontal configuration of lava flows and Rapakivi sheets is not the result of an extensive breaking down by erosion, but constitutes a true reflection of their underlying base.

The real sub-Jotnian unconformity is consequently to be sought, not above, but below the Dala series at the base of the conglomerate topping the Noppi-series. This unconformity marks a greater hiatus than the one previously assumed, indicating a great change, not only in the peculiarities of climate, but also in the orogenic activity.

During the preceding Loos and Noppi periods, the region must have been partly submerged, as verified by the type of sedimentation, the subsiding troughs of sedimentation getting shallower as time went on (cf. the ripple marks of the Noppi sediments). The following uplift of the earth crust may have been connected with the batholitic intrusion of the Rätan granite, as responsible for the last folding of the region. The orogenic agencies must have been active during some time following the congealing of the granite, as recorded by the optical unhomogenity of its quartz grains.

During the dying out of this orogenesis, and after its close, the great unconformity was developed, leading to a complete breaking down of the mountain chains and a gradual levelling of the country. Within this unconformity the erosion must have been considerable, amounting to thousands of metres of rocks, before the great Rätan area was laid bare. Of the sedimentary deposits of this epoch little or nothing remains, the fragmentary remains being confined to the coarse-grained quartzitic conglomerates overlying the Noppi sediments and the Rätan granite, and partly found as agglomeratic inclusions within the basal flows of the Dala porphyries. On to this levelled surface the Rapakivis ejected their lavas in a way recalling the extrusion of the plateau-basalts of upper cretaceous and tertiary age.

The renewal of the Jotnian magmatic activity, unaccompanied by any great tectonic disturbances, gives food for thought. It suggests a, locally, very restricted and not very deep-seated volcanism within parts of the earth crust, which had already attained a rather high degree of stability. One may, perhaps, — on the basis of the apparent agreement, magmatic if not tectonic, of the Rätan and the Rapakivi magmas — conceive a local slow continuation of the differentiation process below the Rätan batholites, or even a remelting of their bottom parts owing to subsidence during the folding period. In any case, the Rapakivi magma must have drilled its way upwards with a slow stooping action, its-low tension character being fairly evident from its mode of extrusion.

At the first extrusion of the Dala-porphyries, climatical conditions were not very greatly changed, even if the ground may have been raised above sea-level. The basal congolmerates furnish no evidence of an arid climate. As the volcanism proceeded, however, the arid weathering made itself noticeable in the reddish inter-Jotnian sedimentation, even if locally, for instance, at Helvetesfallet, one may in the basal strata encounter gray sediments. The renewed outpourings of porphyrites and intrusion of granites following on this earlier sedimentation, and separated from their forerunners by the erosion interval, must have occurred under the same climatic conditions as those ruling during the early and late Jotnian period of sedimentation. The extensive conglomerates of the inter-Jotnian period are, habitually, the same as the late Jotnian. The classification of the porphyries — the older as well as the younger series — as Jotnian is, consequently, fully justified, if by Jotnian we understand a definite period of settled climate and undisturbed tectonics. The sedimentation of this epoch must have occurred under arid desert conditions, as verified by wind-polished sand and boulders, the deposition of the erosion products taking place partly on land and partly in slowly subsiding basins.

The first type is exemplified by the sandstones around Helvetesfallet, which are of such fine grain that they might be supposed to represent the shifting dunes of a desert. The latter is represented by the Malung area, where ripple marks and sun-cracks are found right through the whole pack of sediments of some 800 m. thickness. Those ripple marks cannot very well have developed over this big area in layer upon layer in any other way than by the slow sinking of a very shallow basin.

Summarising my conception of the Jotnian, this epoch is marked by four magmatic periods and three periods of sedimentation in descending order, as follows:

Youngest: (1) Intrusion of late-Jotnian doleritic Åsby diabase.
(2) Sedimentation of upper-Jotnian sandstones.
Weathering and slight erosion of effusives, leading to agate-conglomerates.
(3) Extrusion of effusive Öje-diabase.
Intrusion of inter-Jotnian doleritic Åsby diabase.
(4) Sedimentation of inter-Jotnian sandstones.
Weathering and erosion of Upper Dala series, leading to arkoses and lateritic clays, exposing some of the earlier, as well as later, Rapakivi granites.
(5) Extrusion and intrusion of the Upper Dala series in the following order:
Rapakivi granite.
Quartz-porphyries.
Porphyries.
Syenitic porphyries.
Green or red porphyrites.
Early Jotnian doleritic Åsby diabase.
(6) Sedimentation of early Jotnian sandstones.
Weathering and erosion of Lower Dala porphyries, exposing some of the early Rapakivi granites, and leading to heavy conglomerates and some sandstone.
(7) Intrusion and extrusion of Lower Dala series in the following order:
Rapakivi granite.
Porphyries.
Oldest: Syenitic porphyries.

Great unconformity of the sub-Jotnian (Hoglandian) conglomerates.

The Chronological Succession of the Loos-Hamra Region.

As already intimated, the fragmentary remains of the leptite series of the region do not allow of any chronological comparison being made with the leptite areas of Central Sweden.

The enormous eruptive breccia of these parts has left large xenolithic areas metamorphically relatively untouched, while at Loos the migmatisation has spared nothing but insignificant fragments.

The only comparison to be made within the old archæan would be one between the Mansjö-series and the corresponding eulysite-limestone deposit at Tunaberg, in the province of Södermanland. The position of the latter within the leptite-succession is, however, not quite clear. Still, the occurrence of manganese in both localities indicates that similar climatic conditions may have prevailed during the period of sedimentation.

Generally speaking, the leptite-formation of Central Sweden has been found to consist of a lower division of rocks of volcanic and pyroclastic origin and an upper, sedimentary division. Oldest are the sodic leptites associated with limestones; the potassic leptites representing a later period of the volcanic activity associated with dolomitic carbonates.

The migmatites of the Loos-area are partly potassic and partly decidedly sodic. The preserved leptite xenoliths, too, present the same variation. No attempt has been made to work out a stratigraphy based on that chemical variation, the depth of the present erosion level making such work valueless. The accession of volatiles and pegmatitic solutions has been so great, that the primary chemical characteristics must certainly have been largely obliterated.

Reference has already been made to the amphibolitic intrusions of Mansjö possibly being contemporaneous with the intrusion of the greenstone-dykes marking the conclusion of the first orogenic and metamorphic epoch of Central Sweden. The intense schistosity of the Loos-area, imposed on the rocks during the migmatitization-epoch, has, however, obliterated most of the primary evidences of the intrusive character of those dykes. These may, consequently, in parts be metamorphosed calcareous sediments, too.

On the other hand, the greenstone-intrusion at Loberget, may be contemporaneous with the greenstone-dykes of Central Sweden, but show a puzzling chemical and petrographic affinity to the Svensbo dykes. The last-named dykes unmistakably cut across the general strike of the migmatitization, being apparently of post-migmatitic age.

All told, the remains of pre-migmatitic unmetamorphosed rocks are too few to allow of any reliable conclusions being drawn.

Actually, the earliest unmistakable chronological connection between the Hamra-Loos region and that of Central Sweden is the period of the intrusions of the Mansjö and Stockholm granites and the accompanying migmatitization. The identical chemical, petrological, and tectonic features of these two granites may be taken as a firm basis for correlation.

In Central Sweden, no sedimentation epoch separating the greenstone dykes and the intrusion of the palingenetic granites of Group II has been convincingly shown to exist. It is true that the gray slates covering the leptite-series of Grythyttan are overlain by a conglomerate, which has not been found to be intersected, either by older or younger granites, and of whose age, consequently, nothing can be said with certainty. Its tectonic features, however, point to its being younger than the granites of Group II, although SEDERHOLM (32) classified it as Bothnian, viz as older than the granites of the central area in Finland and Stockholm. The weathering-breccia unconformity claimed by SEDERHOLM as existing between the Bothnian Tammerfors-sediments and a dioritic differentiate of the oldest granites of Group I, has been interpreted by other authors as an eruptive breccia. MCCALLIEN's observation of phenomena in the sediments which may be interpreted as current beddings, makes it doubtful whether the slate-series are not »younging» in a direction opposite to that assumed by SEDERHOLM. The granite-conglomerate, found by SEDERHOLM at Enklinge, and which he claimed to be additional evidence of unconformity, is held by my colleague MAGNUSSON and myself to be, possibly, a tectonic pseudo-conglomerate.

The Skellefteå-schists were also classified by SEDERHOLM as Bothnian. GRIP (9) recently published a paper, however, showing the Arvidsjaur-porphyries, which are younger than the schists, to be intersected by granite, presumably of Group I and older than the Revsund granite of Group II.

In the Loos-district there is no evidence of any great sedimentary series immediately preceding the Mansjö granite. The only strata comparable with the Bothnian schists would be the somewhat doubtful sparagmitic quartzite at the base of the Loos-series, which seems to be invaded by the Mansjö granite.

If, however, the Dåasen granite is taken as a separate granite, independent of the Risberg group, a correlation of the sub-Loosian schists with the Skellefteå as well as with the Tammerfors schists, may be tentatively suggested.

The relationship between the old granites of the Skellefteå field and the old granites of Central Sweden is by no means clearly established, even if the first mentioned are, undoubtedly, the oldest in their district.

Neither is the relation of the different varieties of the big group of Finnish central granites to the granites of Central Sweden based on anything more substantial than circumstantial evidence.

One may conceive a somewhat younger age for the old granites of the Skellefteå area, as well as a chronological range of the Finnish central granites including both the Mansjö and Dåasen granites.

This would, in SEDERHOLM's terminology, make the sub-Loosian schists Bothnian.

If, on the other hand, only the sparagmitic quartzites were Bothnian, the ascending succession of sub-Loosian schists would have no counterpart within Central and Southern Sweden, but may in Finland be correlated with the lower quartzites of SEDERHOLM's Karelidic cycle.

The correlation of the unconformity underlying the lower Loos series also presents difficulties.

In Central Sweden, a distinct period of diastrophism preceded the intrusion of the granites of Group III (Filipstad granite), and was accompanied by renewed volcanic activity and sedimentation, of which scattered remains occur in Central Sweden, such as the Småland porphyries, and the Åmål formation. In Finland, the epoch is represented by the wide-spread Karelian schists and quartzites.

The lower Loos-series, the porphyries especially, may be correlated with the Småland-porphyries and the Risberg granite with the granites of Group III. This correlation is, however, only suggested by the petrological correspondence between the southern and northern rocks. On the other hand, its contemporanity with the porphyries, porphyrites, tuffs, agglomerates and quartzites of the Åmål-series remains doubtful. The assumption of a synchronal age would be strengthened if the sub-Loosian schists could be included in the lower Loos-series. The unmistakable unconformity of the bedding planes, even if at a low angle, apparently excludes an unbroken succession.

There is, however, a possibility of an erosion having occurred, originated by local regression during the sub-Loosian sedimentation. Oscillatory crust-movements may have resulted in »contemporaneous denudation». This would have led to a slight unconformity between the volcanic lava flows and the underbedding sediments, although no chronological epoch would have separated the volcanism and the sedimentation.

In view of the somewhat doubtful position of the sub-Loosian series, this alternative suggestion of a lower-Loosian age must not be ignored.

Turning to the upper-Loos series, no corresponding sediments from Central Sweden have been described so far, which may be explained as the immediate erosion-products of the land surface originated by the extrusion of the Småland and Åmål-porphyries and the intrusion of the Småland and Filipstad granites.

In consequence of the two great unconformities, one overlying the upper Loos series and the other underlying the sub-Loosian series, the author prefers to comprise this geological period under the term Upper Archæan.

The former unconformity also indicates a change in the character of the orogenic agencies; no very great mountain folding and »regional» dynamic metamorphism having occurred in post-Loosian times.

A correspondence may be found to the sediments of the Noppi-series in the Dal-formation — not to be confused with the Dala-series. It lies unconformably on the strongly folded Åmål-formation, and is unaffected by the great distrophism of Southern Sweden which supersedes the intrusion of the granites of Group III. This latter diastrophism is not represented within the Loos-Hamra region. It is suggested by the writer, however, that the folding of the upper Loos-series may have been contemporaneous.

In his preliminary report of 1934, the author suggested that the upper Loos sediments are synchronal with the Vargfors conglomerate, which at that time was known to be younger than the Revsund granite. A. Högbom, however, has shown that the Sorsele granite intersects the conglomerate. The present author has had an opportunity of studying the Vargfors conglomerate in the field, and has found it petrographically very different from the upper Loos-series, and to be more like the basal conglomerate of the Dala series. Such a correlation, however, leads to difficulties, as the Sorsele granite has been assumed to be of the same age as the Rätan granite. The latter, on the other hand, is in the present memoir definitely proved to be older than the basal Jotnian conglomerate.

Megascopically, the Sorsele granite is quite different from the Rätan granite. It is also intersected by porphyry dykes very similar to the Dala porphyries. The correlation of the Vargfors conglomerate and the basal conglomerate W. of the Noppikoski would lead to the conclusion that the Sorsele granite is of the same age as the older Rapakivi granite.

The writer is not in a position to judge whether such a correlation is reasonable or not. He must say, however, that the Sorsele granite did not give him the impression of being petrographically of Rapakivi age.

The difficulties with regard to the granites are avoided if the Vargfors conglomerate and the Noppi-series are correlated. Even in such a case, however, petrological and metamorphical discrepancies would still remain between the two series.

In this connection a few words may be said respecting the correlation of granites far removed from each other. The synchrony of two plutonic magmas will always be rather uncertain as long as we know nothing either of the length of the period during which a magma may be kept fluid, or of the rate at which the differentiation processes take place. A granite differentiate may be kept at a stable composition for some considerable time if the pressure and temperature do not change.

The age of a granite is a relative conception associated with a comparatively shallow erosion section of the earth-crust. We have no guarantee as to which of two magmas — the one intruding the other — is really the younger one. The invaded magma may have reached the level at which it is uncovered to-day later than the invading one, which may nevertheless have been differentiated at an earlier date. One and the same magma may even have been split into two or more separated magma portions displaced laterally and each working its own way at different accelerations to higher levels.

The consequence of such reasoning would be that a magma intruded into one locality at one orogenic period might actually be genetically contemporaneous with another intruded some distance away during a later period.

The Sorsele granite may be of Rätan age, even if it should be proved to intrude into basal Jotnian conglomerates — the geographic surface-distance between the two being great enough to account for a very considerable difference in their rate of ascension. Or it may represent a magma of no plutonic correspondence within the Loos-Hamra region.

Only very great orogenic and magmatic paroxysms of regional character, occurring at about the same stratigraphic level, may be taken with a resonable degree of verisimilitude as evidence of synchronal age. The diastrophism following upon the intrusion of the palingenetic Stockholm and Mansjö granites may be cited as an example. Even in this case the correlation cannot safely be extended over too great distances. The Bohus granite of S.W. Sweden has been suggested as representing a palingenetic granite of a subsidence area, — but is probably considerably younger than the granites of Group II.

In Finland, SEDERHOLM has tried to bridge part of the great gap between the end of Lower Archæan time, at the close of the above mentioned diastrophism, and Jotnian times, by creating a chronological sequence based on the Karelian schists, the Petrosavodsk and Hoglandian sediments and the injection of plutonic and eruptive rocks. Unfortunately, the scarcity of outcrops and the large areas scarcely yet covered by any detailed survey make this chronology seem to be based more on intuition than on actual facts. At a lecture given by

SECTIONS OF THE
LOOS-HAMRA REGION

BY

HARRY VON ECKERMANN

LEGEND

Dala Series

- ▨ *Monzonite*
- ■ *Doleritic Diabase*
- ■ *Rapakivi Granite*
- ▨ *Younger Porphyry*
- ▨ *Porphyrite*
- ▨ *Jotnian Sediments*
- ▨ *Porphyry Tuff*
- ▨ *Older Porphyry*

Noppi-Series

- ■ *Rätan Granite*
- ▨ *Younger Quartzite*
- ▨ *Slate and Graywackes*
- ▨ *Tuffitic Schists*
- ▨ *Quartz-Porphyry*
- ▨ *Older Quartzite*

Upper Loos-Series

- ▨ *Younger Quartzite*
- ▨ *Slate and Graywackes*
- ▨ *Older Quartzite*

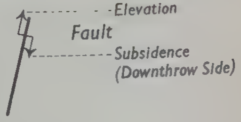
Lower Loos Series

- ■ *Risberg Granite*
- ▨ *Acid Tuffitic Schists*
- ■ *Porphyry*
- ▨ *Basic Tuffitic Schists*
- ▨ *Greenstone*
- ▨ *Effusive Greenstone*

Sub-Loos-Series

- ▨ *Younger Quartzite*
- ▨ *Biotite-Sericite-Schists*
- ▨ *Sillimanite (Andalusite)-Cordierite-Schists*
- ▨ *Older Quartzite*
- ▨ *Sparagmitic Quartzite*

- ▥ Old Archæan



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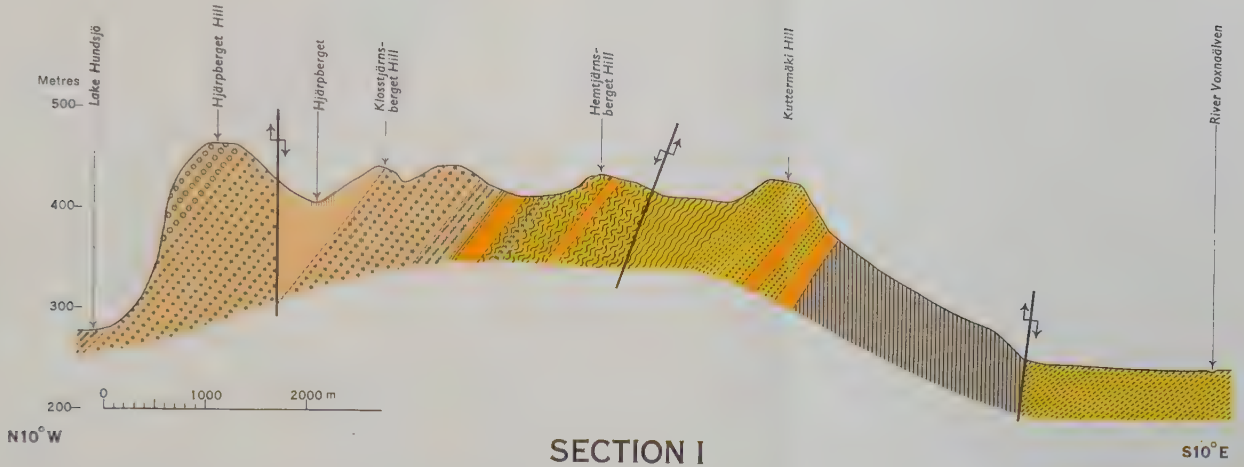

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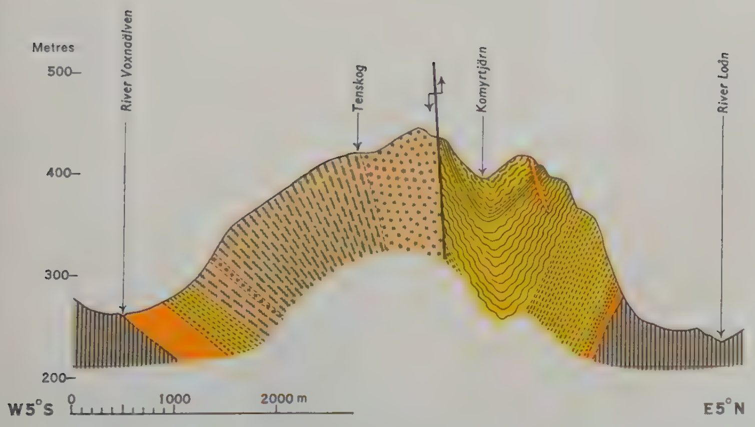

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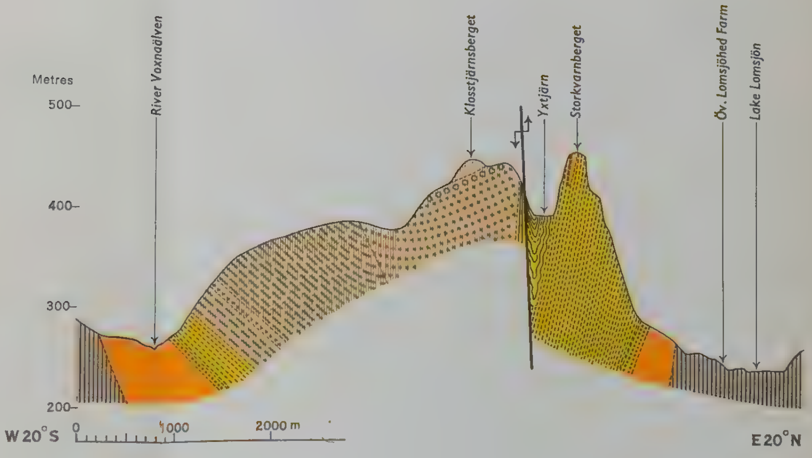

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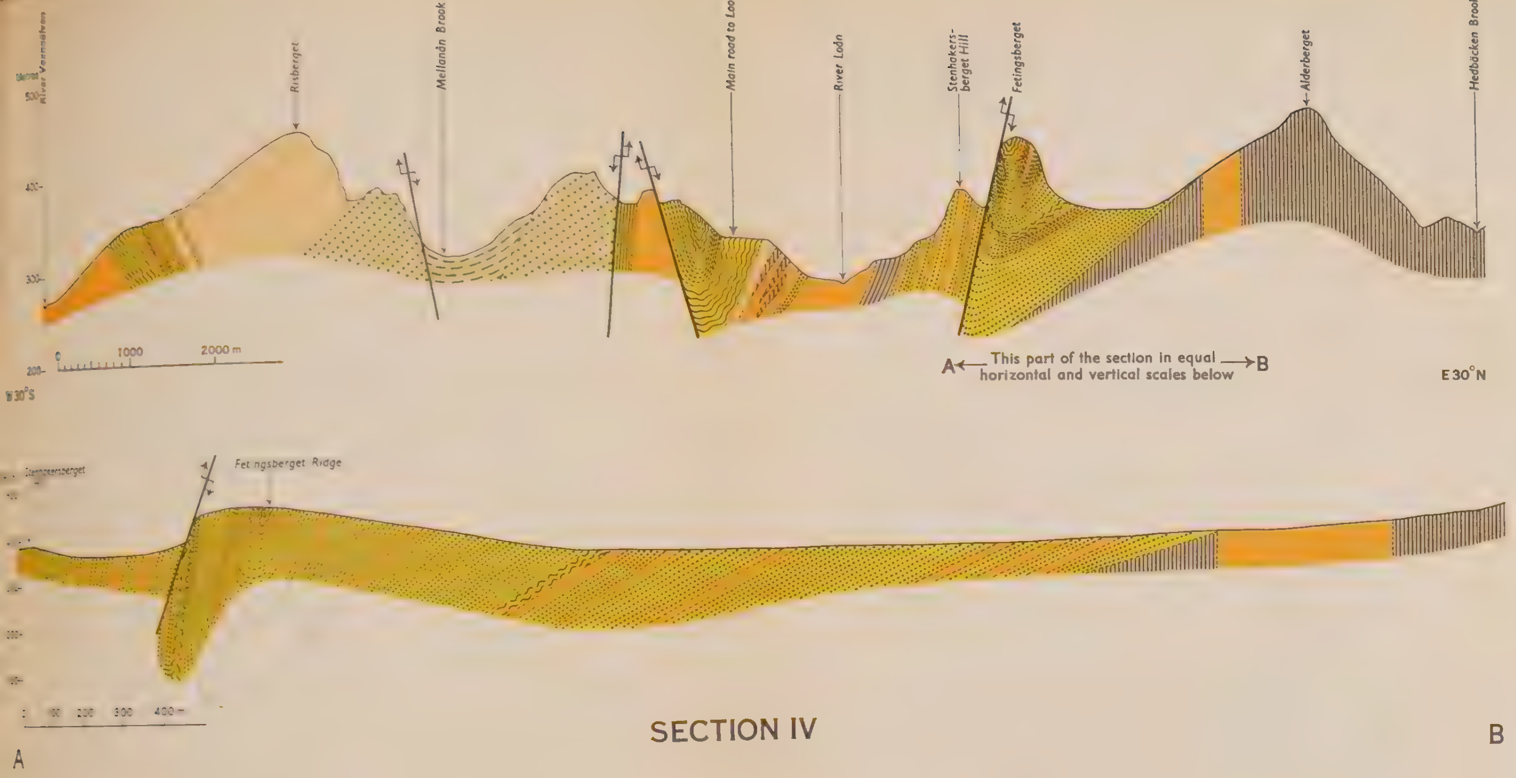

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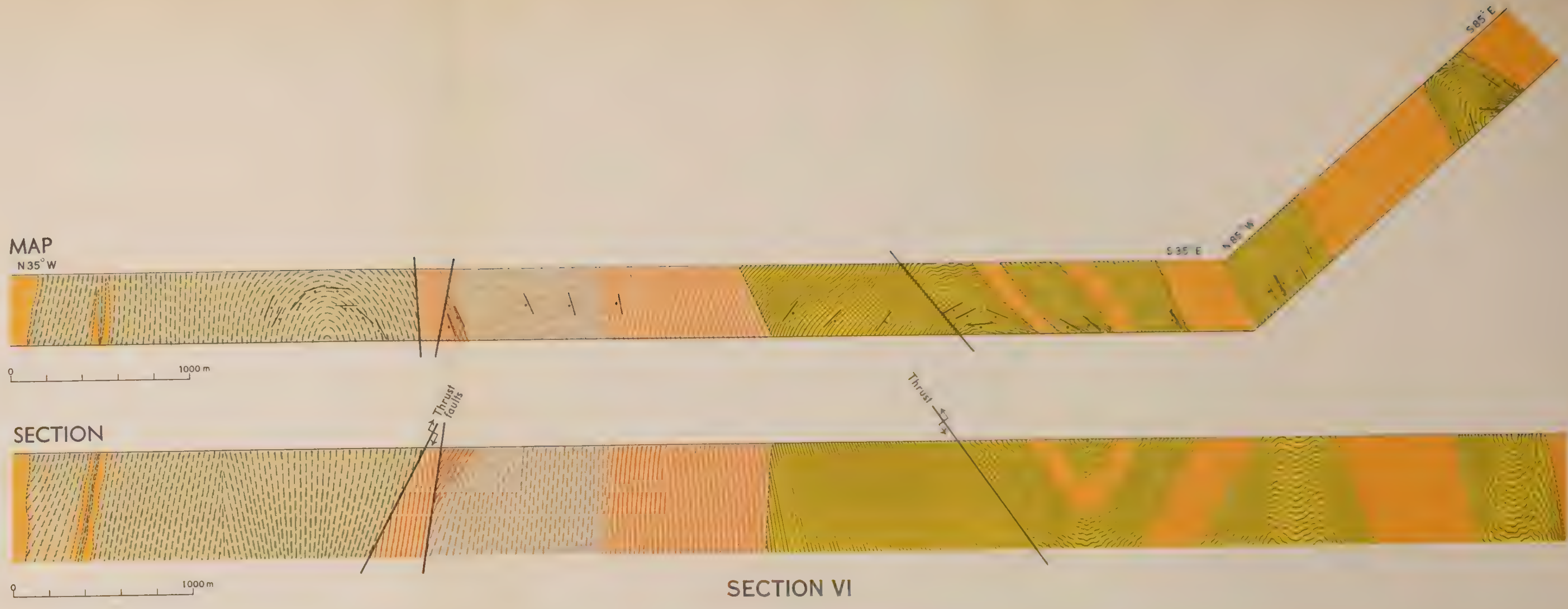

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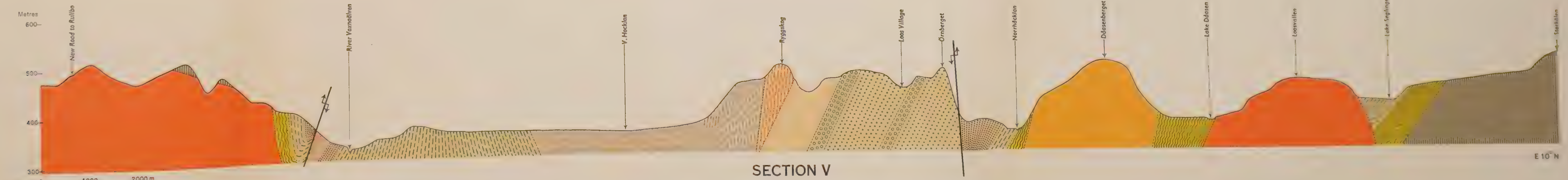

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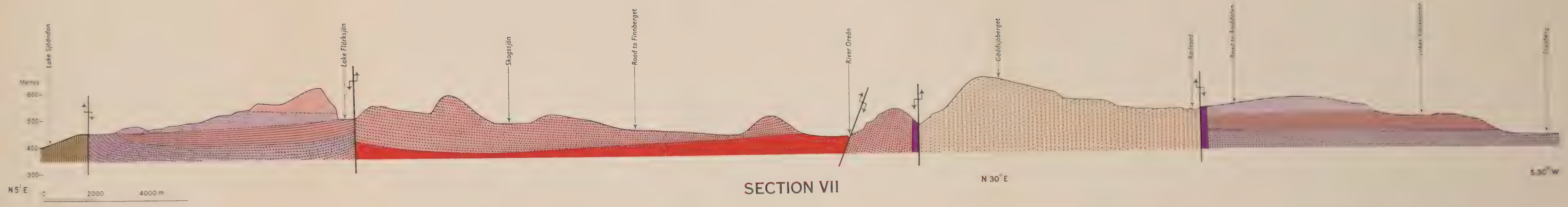

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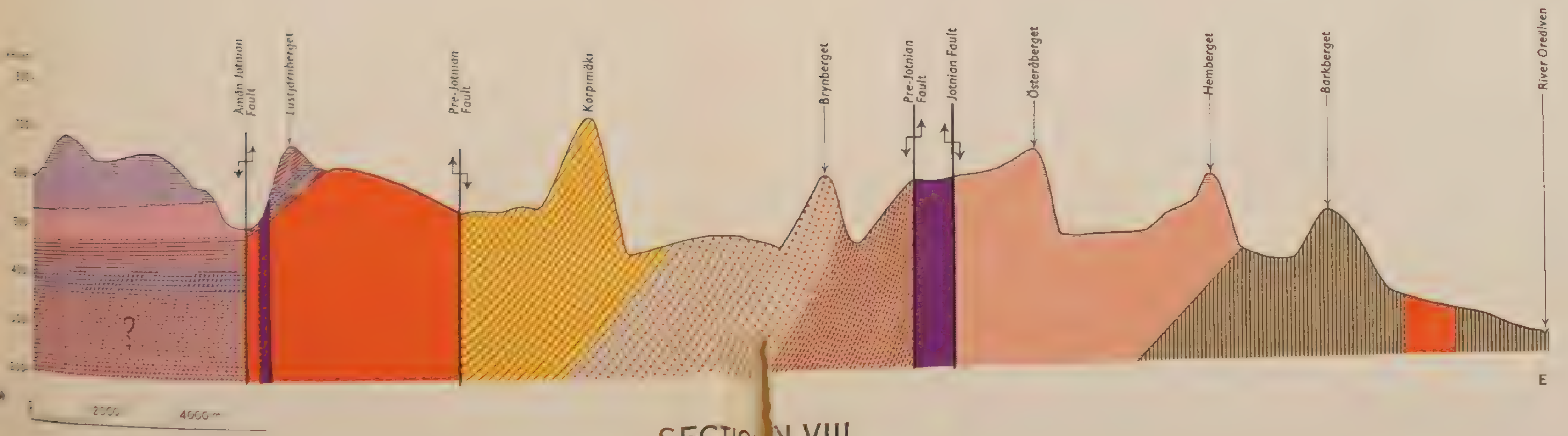

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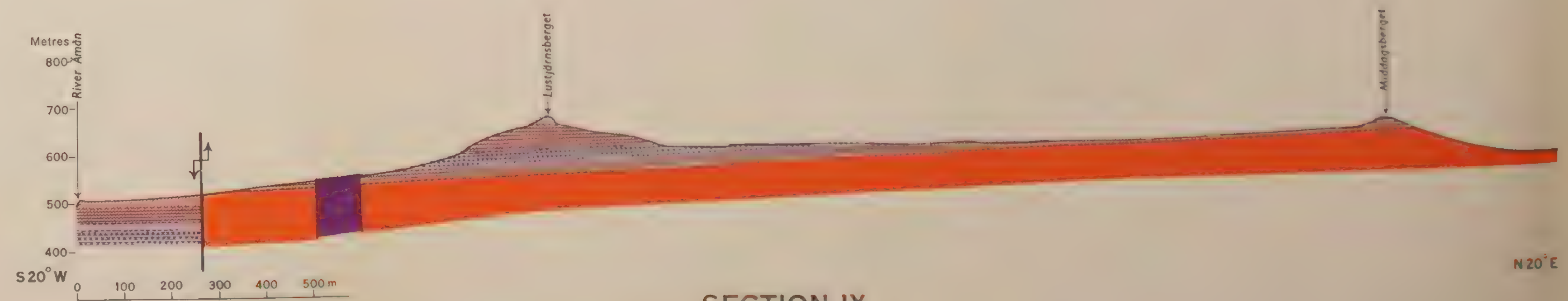

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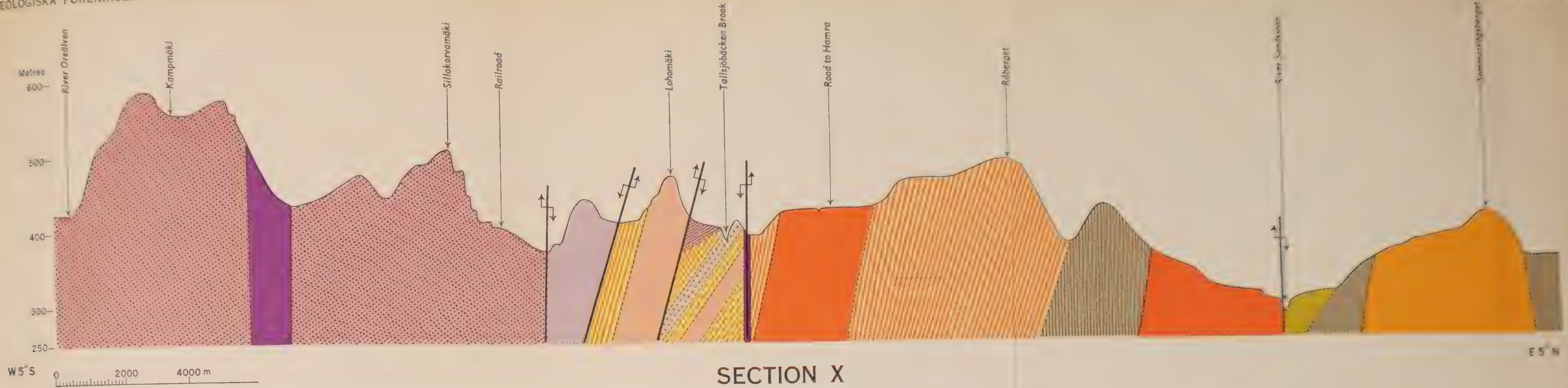

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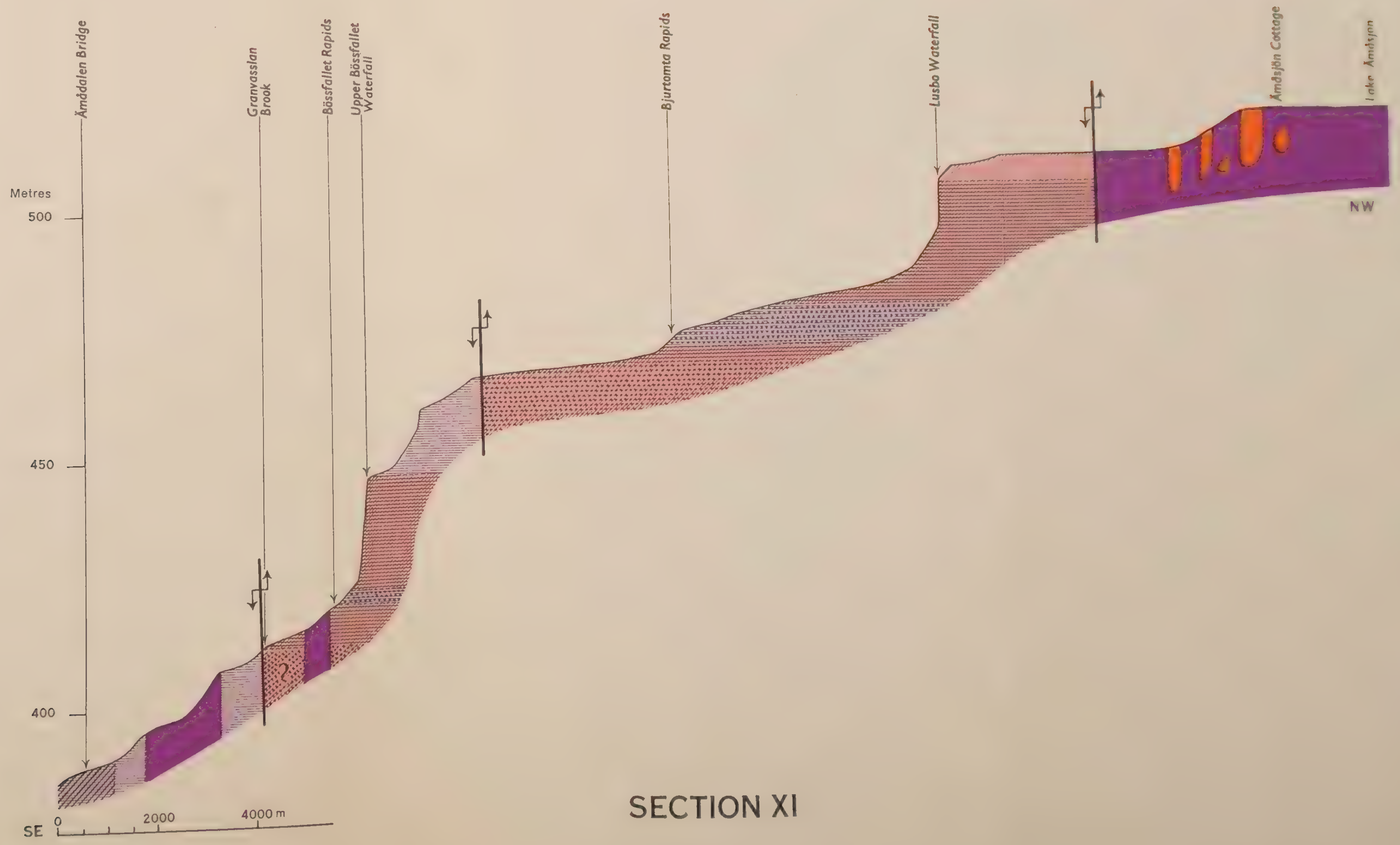

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the present author at Helsingfors some years ago, SEDERHOLM (shortly before his death) suggested that the upper Loos sediments might be of an early Karelian age.

On the same occasion he agreed that there existed the probability of a correlation between the basal conglomerate of the Jotnian series and the Hoglandian conglomerate. This would make the Hogland quartz-porphyry, previously assigned by SEDERHOLM to the later pre-Cambrian, contemporaneous with the Noppi porphyries.

In the writer's preliminary report, he assigned a »Noppi-age» to the Swedish Almesåkra formation, in consequence of its petrological resemblance to the conglomerate on top of the Noppi-series. As the conglomerate in question has now been shown to be the basal one of the Dala series, the Almesåkra series must, consequently, be contemporaneous with the Hoglandian formation. This is to some extent confirmed by the pebbles of the Almesåkra conglomerate being found as inclusions in doleritic diabase of presumable Jotnian age. At the time those pebbles were engulfed by the diabase, the conglomerate must still have occurred as uncemented pebbles. Theoretically, their age is limited downwards by the sub-Jotnian unconformity and upwards by the late-Jotnian age. The climatic conditions ruling at the time of the cementation, however, were not arid, or the conglomerate would have displayed the red colour of the Jotnian sediments. The evidence, consequently, is in favour of a sub-Jotnian sedimentation of Hoglandian age.

On account of the intermediate position occupied by the Noppi and Hoglandian series, between the Upper Archæan and the Jotnian, the author proposes for them the collective term: »Pre-Jotnian».

This nomenclature is also justified by the great unconformity in climatic conditions inaugurated at the beginning of the Jotnian epoch.

In the author's preliminary paper, he assigned a Hoglandian age to the lower Dala series, too, placing the sub-Jotnian unconformity at the base of the younger Dala series. The previous chapter has fully explained the reasons for including these latter series in the Jotnian, limiting the sub-Jotnian Hoglandian to the unconformable sedimentation on top of the Noppi series.

Consequently, the Finnish sandstone area at Björneborg and its diabases are also suggested by the writer to be of Jotnian age, and contemporaneous with the Jotnian sandstones of Dalecarlia and Nordingrå.

Finally, a few words may be said regarding the quartz porphyries at the bottom of the Baltic. Reference has already been made to the probability of their Noppi age (cf. p. 245). Late-Jotnian sandstone occurring at about the same topographical level at Nordingrå and Björneborg, on either side of this sea, suggests a downfaulting of the Baltic »rift» in post-Jotnian, or even post-Silurian, time (cf. the Silurian sediments on the islands outside Gävle and at Kultebo (3, p. 339)).

Knowing the average depth of the Baltic and assuming an average thickness of the Noppi and Dala series, an estimate may even be made of the minimum vertical displacement of this down-faulting. Comparative research of the above-mentioned sedimental areas and the Hamra-Dalecarlia region, supplemented by further study of the tectonic block movements along the coast may limit the errors of such an estimate.

No figures are given, but an estimate based on the present very ncomplete evidence indicates a subsidence of thousands of metres.

Concluding Remarks.

The author is fully aware that his brief discussion of the chronological sequence of the Loos-Hamra region is hardly more than a collection of »buts» and »ifs».

He wishes to emphasize the concluding paragraph of his preliminary paper, wherein he pointed out that the whole of the above correlation is to a great degree tentative and that much more comparative study will be necessary before it is possible — if ever — to finally decide on the likliest interpretation of the riddles.

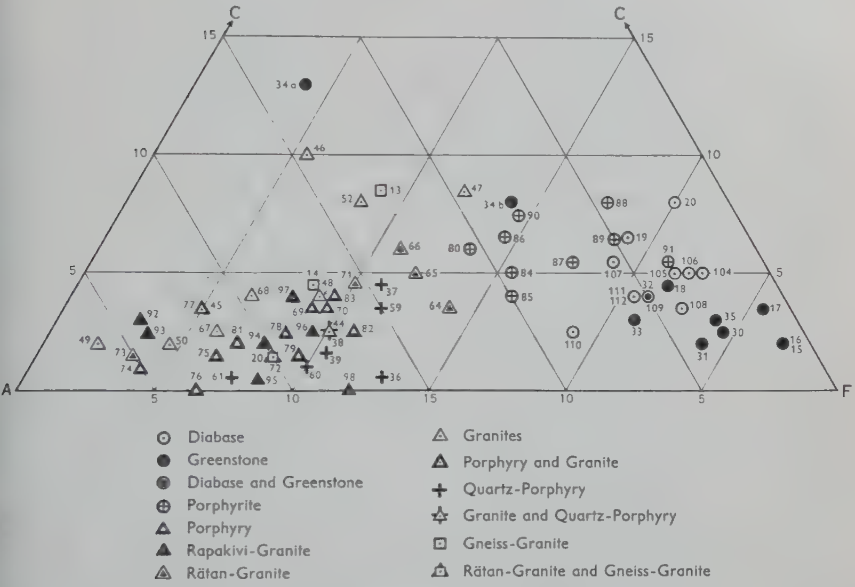
He is also aware of the incompleteness of the present memoir — many important questions being only touched upon, and many mineralogical and petrological problems being treated but cursorily.

The wide field covered by the survey, the manifold varieties of rock-series and the limited space available for publication have necessarily made a detailed description of the localities impossible.

The work, being a one-man job, has, of course, not been executed with the thoroughness characterizing the staff-work of an official department. As, however, the region will not be mapped by the Geological Survey of Sweden for many years to come, the author ventures to cherish the hope of having temporarily filled a blank and made a useful contribution to the geological knowledge of his country.

List of 114 Analyses

published in this memoir.



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In addition to these new analyses, 34 rock-analyses and 29 mineral analyses have been published by the author in previous papers, given as Nos. 2, 4 and 5 in the appended list of references. The localities of the most important of these early rock-analyses are given on the map attached to this memoir.

List of References.

1. Blomberg, A. Praktiskt geologiska undersökningar inom Gefleborgs Län. Sv. Geol. Unders. Ser. C. No. 152. 1895.
2. von Eckermann, H. The rocks and contact minerals of the Mansjö Mt. G. F. F. Vol. 44. No. 349. 1922.
3. ——, A preliminary examination of the profile of the Country rocks along the coast of Southern Norrland, Sweden, as observed in cuttings of the east coast railway. G. F. F. Vol. 50. 1928.
4. ——, H, The graphite deposit at Svensbo. G. F. F. Vol. 49. 1927.
5. ——, En leptitisk, sandstensartad arkos på Stortjärnsåsen i Woxna socken. G. F. F. Vol. 44. 1922.
6. ——, A preliminary report on the Geology of the Loos region. G. F. F. Vol. 56. 1934.
7. Eskola, P. Über die Bottenmeerporphyre. Bull. com. Geol. Finl. No. 104. 1934.
8. Fairbairn, H. W. Spilite and the average metabasalt. Am. J. of Sc. Vol. XXVII. 1934.
9. Grip, E. Die Arvidsjaurporphyre. Bull. Geol. Inst. Upsala. Vol. XXV. 1935.
10. Hackman, V. Das Rapakivi Randgebiet der Gegend von Lappeenranta. Bull. Com. Geol. Finl. No. 106. 1934.
11. Harker, A. Metamorphism. 1932.
12. Holtedahl, O. Tectonic disturbances connected with Plutonic Bodies in the Oslo Region. Am. J. of Sc. Vol. XXIX. 1935.
13. Holmquist, P. J. Om Rödöområdets rapakivi och gångbergarter. Sv. Geol. Und. Ser. C. Nr. 181. 1899.
14. Högbom, A. Nya iakttagelser inom Norr- och Västerbottens urberg. G. F. F. Vol. 53. 1931.
15. Högbom, A. G. Norrland, naturbeskrivning. 1906.
16. ——, Fennoskandia. Handb. d. Rgn. Geol. Band IV. 3. 1913.
17. ——, Jämtlands Län. Sv. Geol. Unders. Ser. C. No. 140. 1920.
18. Kranck, E. H. A Stereogram of Hogland. Fennia 50. 1928.
19. Krokström, T. The Breven Dolerite Dike. Bull. Geol. Inst. Upsala. Vol. XXIII. 1932.
20. Larsson, W. Chemical Analyses of Swedish Rocks. Bull. Geol. Inst. Upsala. Vol. XXIV. 1932.
21. Looström, R. Die Unterlage der Elfdalgesteine. Bull. Geol. Inst. Upsala. Vol. XV. 1916.
22. ——, Åsbydiabasens fältgeologi. G. F. F. Vol. 41. 1919.
23. Magnusson, N. H. Om metamorfosen i det mellansvenska urberget. G. F. F. Vol. 54. 1932.
24. ——, Det mellansvenska urbergets åldersschema. G. F. F. Vol. 55. 1933.
25. Mc Callien, W. J. The Sub-Bothnian unconformity. Geol. Mag. Vol. LXIX. 1932.
26. Nordenskjöld, O. Über basische Ergussgesteine aus dem Elfdalener Porphyrgebiet. Bull. Geol. Inst. Uppsala. Vol. I. 1894.
27. Nockolds, S. R. Some theoretical aspects of contamination in acid magmas. Journ. of Geol. Vol. XLI. 1933.
28. ——, The production of Normal Rock Types by Contamination. Geol. Mag. Vol. LXXI. 1934.
29. Niggli, P. Gesteins- und Mineralprovinzen. 1923.
30. Olivecrona, H. Om Västerdalarnas sandstensformation och dess tektonik. G. F. F. Vol. 42. 1920.
31. Popoff, P. Mikroskopische Studien am Rapakivi. Fennia 50. 1928.
32. Sederholm, J. J. On the Sub-Bothnian unconformity. Bull. Geol. Com. Finland. No. 95. 1931.

    ——, On the Geology of Fennoscandia. Fennia 55. 1932.

    ——, Pre-Quaternary Rocks of Finland. Bull. Geol. Com. Finland. No. 91. 1930.
33. Sobral, J. M. The Geology of the Nordingrå District. 1913.
34. Svedmark, E. Geol. meddelanden. G. F. F. Vol. 13. 1891.

    ——, Orsa Finnmarks Geologi. G. F. F. Vol. 17. 1895.

35. TILLEY, C. E. Metasomatism assoc. with the Greenstone-hornfelses of Kemitjack and Botallack. Min. Mag. Vol. XXIV. 1935.
36. WAHL, W. Die Gesteine des Wiborger Rapakivigebietes. Fennia 45. 1925.
37. WEGMANN, C. E. Zur Deutung der Migmatite. Geol. Rundschau. Bd. XXVI. 1935.
38. WEIBULL, M. Västra Silfbergsfältet i Norrbärke. Lunds Univ. Årsskrift. Vol. XXXIII. 4.
39. ÖSTBERG, C. Mineralog. beskrivning över Färila, Ovanåkers och Woxna socknar. Järnk. Annaler. 1838.

Några nyfunna gadolinitkristaller från Ytterby.

Av

L. O. Martin.

(Manuskr. inkommet $^{10}/_{3}$ 1936.)

Materialet, å vilket föreliggande undersökning är utförd, utgöres av 3 st. kristaller, som av dåvarande teknologen J. Stålhed och författaren insamlades under ett besök vid Ytterby i början av maj månad 1934. Fynden gjordes i gamla varpen. Flera huvudsakligen av fältspat bestående pegmatitstycken hittades, i vilka rätt stora gadolinitkristaller med en mer eller mindre fullkomlig idiomorf begränsning sutto insprängda. Ur dessa pegmatitstycken kunde utom ett flertal kristallfragment med en eller annan yta 3 st. väl utbildade kristaller framprepareras, som visade en sådan formrikedom, att en beskrivning av desamma ansågs vara av intresse.

Samtliga kristaller voro mer eller mindre utpräglat tavelformiga efter basis och mätte mellan c:a 15 × 20 × 8 och 20 × 20 × 20 mm efter respektive a, b och c-axlarna. Samtliga sutto med en mindre del anväxta vid den fältspaten omgivande kloritiserade biotiten och visade ej idiomorf begränsning gentemot denna. Detta betyder att gadoliniten från Ytterby kristalliserat efter biotiten men före fältspaten. Ytorna voro i regel litet matta och speglade dåligt. Här och var, särskilt i å vissa ytor lokalt uppträdande sprickor och oregelbundna fördjupningar, syntes spår av ett vitt pulver, antagligen tengerit. Då kristallerna på grund av sin storlek och ytornas beskaffenhet varit svåra att mäta med reflexionsgoniometer ha inga noggranna vinkelvärden erhållits. Varje reflex bestod av ett diffust begränsat ganska ljussvagt skimmer, som i allmänhet höll sig konstant inom ett område motsvarande maximalt ungefär $^{1}/_{2}$° vridning på skalan. I vinkeltabellen ha därför endast vinkelvärden angivits i helgrader eller i vissa fall halvgrader. Värdena äro emellertid tillräckligt noggranna för att tillåta en identifiering av formerna. De stora ytorna ha mätts med kontaktgoniometer, varvid rätt goda värden erhållits.

De små ytorna däremot voro undantagslöst jämnare och mera speglande och kunde mätas med reflexionsgoniometern. Fig. 1 giver en föreställning om en av kristallernas utseende.

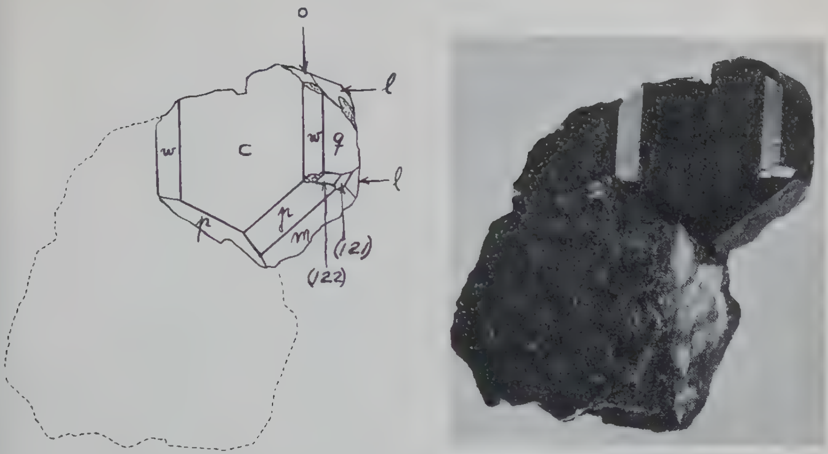

Fig. 1. Fotografi av kristall nr 2 i c:a 2 ggr förstoring.
Å den förtydligande teckningen prickade områden betyda brottytor.

Kristall Nr 1.

Å denna kristall funnos 21 ytor representerande 10 identifierbara former.

Följande former ha observerats:

c {001}; q {011}; w {012}; y {021}; b {010}; m {110};
a {100}; l {120}; p {111}: o $\{\bar{1}11\}$.

Vinkeltabell.

		Mätt.	Beräknat.[1]
q : c	$(0\bar{1}1):(001)$	53°	52° 53′
w : c	$(0\bar{1}2):(001)$	$33^{1}/_{2}$°	33° 27′
w : c	$(012):(001)$	33°	33° 27′
q : c	$(011):(001)$	53°	52° 53′
y : c	$(021):(001)$	59°	58° 40′
b : c	$(010):(001)$	$89^{1}/_{2}$°	90°
q : c	$(01\bar{1}):(001)$	125°	125° 30′
w : c	$(01\bar{2}):(001)$	146°	146° 33′
m : c	$(1\bar{1}0):(001)$	$89^{1}/_{2}$°	89° $31^{1}/_{2}$′
a : c	$(100):(001)$	$89^{1}/_{2}$°	89° $26^{1}/_{2}$′

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[1] Så gott som uteslutande enl. J. Schetelig (Videnskapsselsk. Skr. Mathem.-Naturv. Klasse 1922 no. 1 sid. 105, Kristiania 1922) samt Dana.

			Mätt.	Beräknat.
m : c	(110) : (001)		89½°	89° 31½′
m : c	$(\bar{1}10)$: (001)		90°	90° 28½′
m : c	$(\bar{1}\bar{1}0)$: (001)		90°	90° 28½′
p : c	$(1\bar{1}1)$: (001)		67°	67° 41½′
p : c	(111) : (001)		67°	67° 41½′
o : c	$(\bar{1}11)$: (001)		68°	68° 30′
o : c	$(\bar{1}\bar{1}1)$: (001)	c:a	68°	68° 30′
l : l	(120) : $(\bar{1}20)$		77°	77° 7′
w : q	(012) : (011)		19½°	19° 26′
o : o	$(\bar{1}11)$: $(\bar{1}\bar{1}1)$		59°	58° 53½′
p : p	(111) : $(1\bar{1}1)$		59°	59° 16′
o : p	$(\bar{1}11)$: (111)	c:a	103°	103° 37½′
p : q	(111) : (011)		51°	51° 41′
o : q	$(\bar{1}11)$: (011)	c:a	52°	51° 56½′
m : m	$(1\bar{1}0)$: (110)		64°	64° 12′
m : m	(110) : $(\bar{1}10)$		115½°	115° 48′
w : w	$(0\bar{1}2)$: (012)		67°	66° 54½′
q : q	$(0\bar{1}1)$: (011)		106°	105° 46′
a : p	(100) : $(1\bar{1}1)$		38°	38° 3½′

Kristall Nr 2.

Denna kristall har 20 ytor representerande 10 identifierbara former. Den har de jämnaste och bäst speglande ytorna och äger i stort sett samma habitus som den föregående. Tyvärr begränsas kristallens bortre del så gott som uteslutande av gamla brottytor. Dock är pyramidformen p {111} kraftigare utvecklad, under det att ortopinakoiden a {100} ej säkert kunnat identifieras.

Följande former ha observerats:

c {001}; q {011}; w {012}; b {010}; m {110}; l {120};
p {111); o $\{\bar{1}11\}$; {121}; {122}.

Vinkeltabell.

		Mätt.	Beräknat.
q : c	$(0\bar{1}1)$: (001)	53°	52° 53′
w : c	$(0\bar{1}2)$: (001)	33½°	33° 27′
w : c	(012) : (001)	33½°	33° 27′
q : c	(011) : (001)	53°	52° 53′
b : c	(010) : (001)	90°	90°
q : c	(011) : $(00\bar{1})$	54½°	54° 30′
w : c	$(01\bar{2})$: $(00\bar{1})$	33½°	33° 27′
m : c	(110) : (001)	89½°	89° 31½′
m : c	$(\bar{1}10)$: (001)	90°	90° 28½′
p : c	$(1\bar{1}1)$: (001)	67½°	67° 41½′
p : c	(111) : (001)	67½°	67° 41½′
o : c	$(\bar{1}11)$: (001)	68°	68° 30′

		Mätt.	Beräknat.
l : l	(120) : $(\bar{1}20)$	77°	77° 7′
w : q	(012) : (011)	19$^1/_2$°	19° 26′
p : p	(111) : $(1\bar{1}1)$	59°	59° 16′
o : p	$(\bar{1}11)$: (111)	103$^1/_2$°	103° 37$^1/_2$′
p : q	(111) : (011)	51$^1/_2$°	51° 41′
o : q	$(\bar{1}11)$: (011)	52°	51° 56$^1/_2$′
m : m	(110) : $(\bar{1}10)$	116°	115° 48′
w : w	$(0\bar{1}2)$: (012)	67°	66° 54$^1/_2$′
q : q	$(0\bar{1}1)$: (011)	106°	105° 46′
c : (121)	(001) : (121)	70°	70° 30′
c : (122)	(001) : (122)	60°	59° 28′
q : (122)	(011) : (122)	32°	32° 40′
o : (122)	$(\bar{1}11)$: (122)	20°	19° 56′
l : (121)	(120) : (121)	17°	17° 20′

Kristall Nr 3.

Denna kristall har 12 ytor representerande 9 bestämbara former. Den är den mest deformerade och mest ofullständigt utbildade av de tre. Å de bägge föregående dominerade basisformen och gav kristallen en tavelformig utbildning. Å denna kristall uppträda prismorna såsom dominerande former och kristallen har därigenom i förhållande till de föregående en mera isometrisk habitus. Ytorna äro oftast rätt jämna och glänsande. Kanterna äro dock sällan hela.

Följande former ha observerats:

c {001}; q {011}; w {012}; b {010}; m {110}; l {120};
p {111}; o $\{\bar{1}11\}$; a {100}.

Vinkeltabell.

			Mätt.	Beräknat.
q : c	$(0\bar{1}1)$: (001)		52°	52° 53′
w : c	$(0\bar{1}2)$: (001)		33°	33° 27′
w : c	(012) : (001)		33$^1/_2$°	33° 27′
b : c	$(0\bar{1}0)$: (001)	c:a	90°	90°
m : c	(110) : (001)		89$^1/_2$°	89° 31$^1/_2$′
m : c	$(1\bar{1}0)$: (001)		89°	89° 31$^1/_2$′
m : c	$(\bar{1}10)$: (001)		89°	90° 29$^1/_2$′
a : c	(100) : (001)		89$^1/_2$°	89° 26$^1/_2$′
p : c	$(1\bar{1}1)$: (001)		67°	67° 41$^1/_2$′
p : c	(111) : (001)	c:a	67°	67° 41$^1/_2$′
o : c	$(\bar{1}11)$: (001)	c:a	68°	68° 30′
l : l	$(1\bar{2}0)$: (120)	c:a	102°	102° 53′
w : q	$(0\bar{1}2)$: $(0\bar{1}1)$		19$^1/_2$°	19° 26′
p : p	$(1\bar{1}1)$: (111)	c:a	60°	59° 16′
p : q	$(1\bar{1}1)$: $(0\bar{1}1)$		51°	51° 41′
m : m	$(1\bar{1}0)$: (110)		64°	64° 12′

Följande sammanställning visar de olika formernas fördelning på de särskilda kristallerna:

Form.	Nr 1.	Nr 2.	Nr 3.
c {001}	×	×	×
q {011}	×	×	×
w {012}	×	×	×
y {021}	×	—	—
b {010}	×	×	×
m {110}	×	×	×
a {100}	×	—	×
l {120}	×	×	×
p {111}	×	×	×
o {$\bar{1}$11}	×	×	×
{121}	—	×	—
{122}	—	×	—

Stockholm i mars 1936.

Till frågan om granitgrupper, bergskedjeveckningar och cykelindelning inom Fennoskandia.

Av

HELGE G. BACKLUND.

(Manuskr. inkommet $^{16}/_{3}$ 1936.)

I ett föredrag i Svenska Mineralogiska Sällskapet, som jag ej haft tillfälle att övervara, men som numera föreligger i tryck, har W. WAHL (1) kommit med synnerligen beaktansvärda synpunkter på principen för behandlingen av vårt fennoskandiska urberg och dess graniter.

I WAHLS synpunkter kan jag endast fullt instämma, emedan sedan mer än 25 år tillbaka mina fält- och laboratorieundersökningar oavlåtligen varit inriktade på studiet av uppträdandet av magmabergarter inklusive graniter av olika åldrar inom gammalpaleozoiska, ungpaleozoiska och tertiära bergskedjor, alltså i de mest olikartade snitt av jordskorpan. Sålunda gåvo mina uppslag (1911/13), att de s. k. andengraniterna och -dioriterna i fält motsvaras av 3—5 olikåldriga graniter resp. dioriter, upphov till intensiva diskussioner i Argentinas Geologiska Undersökning (1912, 1913) samt hade till följd att W. PENCK i sin senare storstilade Atacama-undersökning (2) begagnade dessa uppslag som utgångspunkter för sin diskussion av den andina orogenesen. Till följd av ovidkommande tilldragelser utkom resultatet av mina kombinerade fält- och laboratorieundersökningar något senare i annan form och baserat på något annat material än som ursprungligen planerats (3, 4), men torde dock i sin distinkta formulering vara ett av de första uppslagen i denna riktning. Ungefär samtidigt, eller något tidigare, hade jag på basen av material, som uppsamlats av annan geolog, kunnat konstatera åtminstone två synorogena och en postorogen granitintrusion inom senpaleozoisk (variskisk) bergskedjebildning (5, 6). Något senare hade jag i fält kunnat fastställa (1915, 1917) att inom gammalpaleozoisk bergskedjebildning (Sajanerna, Tannuola) förekommit 1—2 synorogena samt en postorogen granitintrusion, vilket jag i förbigående nämner i notiser med annat syfte (7, 8). Mellankommande omständigheter förhindrade detaljutredningar även i detta fall. Vidare har den med QUENSEL (9) gemensamt utförda karteringen av Västerbottensfjällen visat, att inom de skandinaviska kaledoniderna flera olikartat tektoniskt deformerade, således olikåldriga syntektoniska graniter äro representerade, och att även sen- och posttektoniska graniter där påträffats; detta torde klart framgå av den rel. utförliga teckenförklaringen till kartan, trots att kartbeskrivningen ledsamt nog — jag beklagar det själv mest — ännu ej utkommit. Denna erfarenhet om olikåldriga graniter var vägledande vid fältkarteringen, liksom även principen för grönstenseffusivens i samma bergskedja olika åldersställning (10, 11). Tidigare har GOLDSCHMIDT (12) givit antydningar i samma riktning. Erfarenheten från Västerbottensfjällen visade, att graniter i spåren av grönstenseffusiven, men oavhängiga av dessa, stego högt upp i de skandinaviska kaledonidernas flyschformationer, att de således övertvära stratigrafiska (och tektoniska) diskordanser inom fjällkedjan (13). Slutligen visade mångårig fälterfarenhet från Östgrönlands kaledonider, som i sina strukturer, texturer och sin granitpenetrering i så hög grad påminna om urberget, att geologer med ej alldeles föraktlig erfarenhet från urberget (O. NORDENSKJÖLD 14, A. G. NATHORST 15) karterade berggrunden som urberg, — erfarenheten därifrån visade, att repeterade granitisationer i olika nivåer av sedimentpacken äro nära nog generella, att granitintrusionernas övre gräns ej kan fastställas (16, 17), men att tillsynes »postorogena» granitintrusioner stiga upp t. o. m. i den kaledoniska molassens mellersta delar (devon, 18, 19); emellertid går denna molass, liksom i Alperna, Himalaya, ej fri från veckningsrörelser av rel. ansenlig amplitud (20). Granitintrusioner rapporteras även från kaledonidernas molass i Skottland (21); ej att förglömma kvartstrakyten från W-Norges (mellan-)devon (22). Typiska flyschbildningar ha ännu ej påträffats inom Östgrönlands kaledonider (23); den högsta paleontologiskt dokumenterade stratigrafiska nivån inom ej granitiserade delar av bergskedjan motsvarar ordovicium. Möjligen har flyschen fallit offer för molassnedbrytningen, vars samlade depositionsmäktighet uppgår till över 7,000 m (20).

Med denna samlade fälterfarenhet anser jag mig vara berättigad att yttra ett par ord till diskussionen om fennoskandisk berggrund. Desto mera som även här min fälterfarenhet från talrika exkursioner kors och tvärs i Fennoskandia ej är helt föraktlig och som denna fälterfarenhet i flesta fall följts av laboratoriestudier utan förutfattad mening. Det antal geologer, som anse att erfarenheter från andra fält, även om de ibland med en smula förakt benämnas »exotiska», ej kunna, mutatis mutandis, tillämpas på fennoskandisk berggrund, torde vara ringa, så snart de anslutit sig till den av SEDERHOLM särskilt högt ställda uniformitaristiska tankegången (»aktualitetsprincipen»). Desto mer som jag redan i en föreläsningsserie h. t. 1933 över fennoskandiskt urberg delvis brutit med den gängse åskådningen, för att vid tillfälle när samma föreläsningsserie nästa gång återkom ($^{16}/_{1}$ 1936) helt bryta med densamma. Ty numera (sedan slutet 1935) föreligga de ryska detaljundersökningarna från delar av Kolahalvön (24) och deras översiktliga sammanfattning (25), som man så länge väntat på för att kunna taga steget helt ut. Att grundlinjerna för den nya behandlingen av urbergsproblemen sammanföllo med WAHLS korta principiella skissering, bör ej tolkas som tillfällighet, utan snarare i den riktning att vi äro på rätt spår. För att förhindra misstolkning, som redan synes vara på färde, och för att understrykande av sekundära fenomen ej må ställa de primära riktlinjerna i skuggan och därmed principen avfärdas som ej tillämplig på fennoskandiska förhållanden (26), böra ett par grundlinjer, som WAHL ej framhållit, betonas något starkare.

SEDERHOLM som riktat vår urbergsforskning med så talrika fruktbärande uppslag ansåg sig helt och konsekvent behärskad av uniformitaristiska tankegångar. Bortsett från de detaljfall, där möjligen »aktualitetsprincipen» ej äger full tillämpning på så långt avlägsna tidpunkter det är frågan om i vårt urberg, vill jag påstå, att han ej varit konsekvent i en huvudpunkt; han betraktade Fennoskandia för utpräglat som en nära nog homogen arkitektonisk enhet, vilken vid inträdande deformationstillfällen även i avlägsna tider reagerade likformigt bl. a. genom samtidigt inträngande av »granitmagmor» i olika mer eller mindre tillfälliga delar av de subkrustala formationerna. Att detta hans betraktelsesätt i huvudsak ärvts från den uppfattning kvartärgeologerna ej allt för långt tillbaka ägde om det större Fennoskandia torde ej kunna betvivlas, ehuru studiet av tyngdkrafts- och magnetiska anomalier numera bidrager till att skingra denna föreställning, då anomalierna visa att det nutida Fennoskandia i deformationshänseende ej kan vara varken homogent eller enhetligt. Konsekvenserna av detta betraktelsesätt blev, att en föreställning om en gemensam magmabassäng under Fennoskandia måste postuleras. Vid på varandra i olika delar av Fennoskandia följande »orogena» deformationer uttömdes — under fortgående differentiationer — denna reservoar, kristalliserade delar införlivades med övre delar av jordskorpan, som tilltog i tjocklek, så att de yngre deformationerna i allt mera begränsat omfång förorsakade »magmainjektioner» underifrån, och de yngsta deformationsstråken (och yngsta sedimenten) gingo helt fria eller erhöllo endast minimala materialtillskott underifrån. Graden av granitisering, intensiteten av successiva granitintrusioner, var således ett uttryck för åldern av deformations- eller rättare sedimentstråken; de yngsta voro granitfria. Till detta föreställningssätt, som ej tager hänsyn till de äldre deformationsstråkens starkt och lokalt ökade resistens och därmed isostatiskt förvärvade stigningstendenser jämte angränsande lateralområdens motsatta reaktionsinställning, knyter sig ofrivilligt föreställningen om den »primära stelningsskorpan» eller suprakrustalformationens underlag som den äldsta av dessa cykler; i bakgrunden skymtar även bilden av magmareservoarens eller djupare smältflytande delars slutgiltiga kristallisation med fantastiska strukturer, inför vilka den lika fantastiska non-possumus-tolkningen »likvid differentiation» tillgripes. Bägge dessa sistnämnda nödfallstolkningar uttalades visserligen aldrig av SEDERHOLM själv, som tydligt insåg deras ofruktbarhet, men de antogos dock på annat håll som logisk konsekvens av den ensidigt utnyttjade arbetsmetodiken; ty därtill kom det fatala cirkelslutet, att formationer, eller arealer med de mest fantastiska och kontrastrika »djupmagmatiska flytstrukturer» representera de djupaste horisontalsnitten i jordskorpan, att de således innehava den högsta åldern, en slutledning som på det intimaste sammanhänger med anförda nödfallstolkningar.

Härtill konstaterar WAHL nyktert och klart, att alla bergskedjor äro, oavsett deras åldersställning, »granitinjicerade» och granitiserade, och kunna vara det i lika hög grad. Gränsen härför är dragen endast av det djup, å vilket granitisk »stelning» förekommer, samt erosionsblottning jämte observationsmöjligheter av motsvarande strukturer, således även »ådergnejsbildningar» m. m., betingade endast av den stighöjd det sammanveckade blocket t. f. av jämnviktsbetingade rörelser inom större subkrustala områden förmår prestera. Här skulle jag vilja tillfoga att granitiseringen, resp. granitiseringshöjden inom en och samma bergskedja i dess strykningsriktning är starkt varierande: i vissa delar stiga graniterna, oftast i flera repriser, upp i de geosynklinala sedimentpackornas övre och översta delar, i flyschen, ja t. o. m. i de till bergskedjan omedelbart anslutna nedbrytningsmassorna, d. v. s. molassen, för att i andra delar förbliva osynliga t. o. m. i geosynklinalens tidigaste utfyllningssediment; bergskedjeavsnitt med dylika differenser i stighöjd kunna ligga omedelbart bredvid varandra. Granitiseringen är tillsynes i mindre grad avhängig av den (basiska) ytvulkanismen inom geosynklinalen, som kan uppträda såväl mot slutet av evolutionsfasen — eller vid dess olika etapper —, som vid olika revolutionsfaser inom geosynklinalbildningar. Denna senare kan således vara äldre och yngre än de olika granitiseringsfaserna, således i senare fall med sina skivformiga tilloppsapparater genomskära vissa graniter, som tillhöra samma geosynklinala utvecklingsskede.

Som följd av dessa komplexa aktioner inom geosynklinalen, vilka oftast och repeterat kulminera i smärre eller större revolutionsfaser, uppstå förändrade sedimentationsbetingelser, som taga sig uttryck i lokala och regionala faciesförändringar, »luckor», erosioner med konglomeratbildningar, vinkeldiskordanser av olika typer, och varigenom smärre eller större repetitioner av erosions-sedimentationscykler uppträda; dessa höra dock helt till samma gemensamma större och fortlöpande utvecklingslinje. Vid den senare efterföljande granitiseringen kunna dessa oregelbundenheter lokalt helt utplånas. Uppträdande av konglomerat, även om bland dess bollar djupbergarter äro representerade, kunna således ej vara vägledande för indelningar i *större fullständiga sedimentationscykler* av different ålder, sålänge vägledande fossil ej förefinnas, lika litet som antalet på varandra följande granitisationer kan vara det. Allra minst inom sedimentationsbäcken av så hög ålder som de arkeiska, för vilka i sedimentationshänseende »aktualitetsprincipen» troligen ej äger full tillämpning. Ty medan för postkambriska tiders olikåldriga geosynklinaler ur sedimentens karaktär oftast kunnna avläsas de differenta miljöbetingelser, under vilka vittring, transport och avlagring av utfyllnadsmassorna försiggått, är tolkningen av arkeiska sediment från iknande synpunkter behäftad med stor osäkerhet redan på grund av att organiskt liv varit sparsamt — om alls — representerat. Det kan för så avlägsna tider dock med stor säkerhet förutsättas, att en fullständig sedimentationscykel består av följande uppåt på varandra följande led: normala sediment i den vanliga kvalitativa successionen, flyschbildningar (i en eller flere repriser, åtskilda av mer eller mindre mäktiga normala sediment) samt molassbildningar. Då dessa senaste äro till större delen utpräglade landbildningar, falla de snart offer för fortlöpande erosion och äro endast i undantagsfall bibehållna till nutid. Med ganska stor säkerhet böra de olika, varandra i tid och position avlösande prekambriska sedimentationsbäckena — geosynklinalerna — innehålla mera utpräglat *likartade* sediment än som är fallet inom olikåldriga postkambriska geosynklinaler.

Av vad som ovan anförts framgår med all önskvärd tydlighet, att varken »sedimentationscykler» eller »granitiseringscykler» kunna vara vägledande för en större kausalbetonad indelning av vårt urberg, framför allt ej när det gäller att parallellisera eller sammanställa tvenne representanter av den ena eller den andra cykeln från olika delar av den fennoskandiska arealen. Detta uttalar Wahl tydligt, i det han framhåller bergskedjeveckningen, vars »rötter» vi observera, som enda hållbara princip för en större indelning av vårt urberg, och att *endast bergarter*, magmatogena *eller* sedimentogena, *tillhörande samma likriktade veckningsgrupp, äro omedelbart jämförbara i ålder och position.* Härtill ville jag bifoga följande förtydligande. En bergskedja uppstår enligt gängse uppfattning genom sammanveckning av samtliga sediment inom ett sedimentationsbäcken av geosynklinal karaktär. Veckningsstilen är i stort avhängig av sedimentens olika veckningskompetens, kan alltså växla från etage till etage. Veckens orientering bestämmes av det labila (sedimentations-)områdets (långsträckta) form, av rörelsekomponentens riktning och av ev. stabilområden, som kunnat kvarstå som positiva rester inom geosynklinalens allmänt negativt betonade arealer. Veckaxlarna förlöpa således i allmänhet parallellt eller subparallellt, divergera kring resistensrester, för att åter konvergera på andra sidan om dem, svänga mjukt kring mera motståndskraftiga ojämnheter av sedimentationsbäckenets stabilare ränder. Det bör emellertid understrykas, att liksom sedimentationen inom en geosynklinal kan sträcka sig över flere geologiska »perioder», likaså är sammanveckningen oftast en långsam affär: den äger rum i flere repriser, under vilka veckningen alltmera tillskärpes och varigenom veckaxlarna visa benägenhet att ordna sig i mindre regelbundet uppträdande kulminationer och depressioner. En halvcirkelformig omböjning i dagsytan av strykningen inom i övrigt parallelltgående veck och strykningsriktning är således endast ett uttryck för denna frihetsgrad i rörlighet hos veckaxlarna inom ett konformt veckningssystem, vari halvcirkelns större eller mindre radius ger en föreställning om bergartsledens olika kompetens och kan således ej uppfattas som diskordans i egentlig mening. Senare deformationer inom samma system följa de gamla spåren. Veckningen är således konform, konsekvent och homonom, En mekanisk påfrestning, som gör sig gällande efter att maximal sammanveckning ägt rum, utlöses ofta i en veckning av annan stil, men är fortfarande konform och kallas gärna posthum; denna hör till samma tektoniska system.

Yngre veckningar, tillhörande andra geosynklinalområden, förhålla sig inom sitt eget system likartat som det föregående, men äro med hänsyn till det äldre övertvärande, avskärande, reneganta (27). Varken sedimentationscykler eller granitiseringsfenomen äro till ålder eller position jämförbara mellan system av renegant inbördes ställning. Utgående från dessa principer har jag för någon tid sedan i samband med mina föreläsningar kommit till följande större grupperingar inom fennoskandisk berggrund:

äldst: 1) Svecofennider (södra och sydvästra Finland, mellersta Svealand intill Filipstads bergslag, norra Östergötland).

2) Norvegosamider[1] (Kolahalvön med det nordfinska granulitmassivet och Sydvaranger).
3) Gotokarelider (västra Sverige, södra Norge, norra Sverige, norra Finland och Karelen jämte sydöstra Sverige).
Yngst: 4) Kaledonider.

1) stryker generellt i E—W, 2) i WNW—ESE, 3) i N—S till NNW—ESE och 4) i NNE—SSW. Den yngre gruppen förhåller sig alltjämt renegant med hänsyn till den näst äldre. Sedimentationen kan och bör repeteras inom åtminstone 1—3 var för sig, likaså granitisationer, utan att kunna i åldershänseende eller i övrigt parallelliseras.

Detta schema avviker föga från Wahls, är något fullständigare och mera kausalbetonat. En närmare precisering och utdragandet av de fulla konsekvenserna för denna gruppering är under förberedning för tryck på annan ort och på annat språk.

Litteraturreferenser.

1. Wahl, W., Om granitgrupperna och bergskedjeveckning i Sverige och Finland. G. F. F. 58. 1936. 90.
2. Penck, W., Der Südrand der Puna de Atacama. Abh. math.-phys. Kl. Sächs. Akad. Wiss. XXXVII. No. 1. 1920.
3. Backlund, H. G., Der magmatische Anteil der Cordillera von Süd-Mendoza. Acta Acad. Aboensis Math. et Physica II. Åbo 1923.
4. —, Magmatic Activity and Mountain Folding in the Andes of South Mendoza. Geol. Mag. LXIII. 1926. 410.
5. —, Petrogenetische Studien an Taimyrgesteinen. G. F. F. 40. 1918. 101.
6. —, Kristalle Gesteine von der Nordküste Sibiriens II. Kristalline Gesteine von der Taimyr-Halbinsel. (På ryska; påbörjat i tryck 1914, avslutat i tryckning 1929). Mém. de l'Acad. de Sciences de l'URSS. XXI. No 7. Leningrad 1929.
7. —, Om kemiska förändringar vid metamorfos. G. F. F. 41. 1919. 383.
8. —, Zur tektonischen Gliederung Asiens. Geogr. Annaler XVII. 1935. 242. (Hyllningsskrift Sven Hedin.)
9. —, och Quensel, P., Karta över berggrunden inom Västerbottens fjällområde. Stockholm 1929.
10. —, Försök till magmatektonisk analys av Västerbottens fjällbyggnad. G. F. F. 47. 1925. 155.
11. —, Zur Tektonik des nordschwedischen Hochgebirges. Geol. Rundschau 26. 1935. 429.
12. Goldschmidt, V. M., Übersicht der Eruptivgesteine im kaled. Gebirge zw. Stavanger u. Trondhjem. Vidensk. Selsk. Skrifter. Mat.-naturv. Kl. 1916 No 2. Kristiania.
13. Backlund, H. G., Zur genetischen Deutung des Eklogits. Geol. Rundschau 27. 1936.
14. Nordenskjöld, O., On the geology and physical geography of East-Greenland. Medd. o. Grönland 28. Köbenhavn 1909.
15. Nathorst, A. G., Bidrag till nordöstra Grönlands geologi. G. F. F. 23. 1901.
16. Backlund, H. G., Das Alter des »metamorphen Komplexes» von Franz Josef Fjord in Ostgrönland. Medd. o. Grönland 87. Nr 4. Köbenhavn 1932.
17. —, Contributions to the geology of Northeast Greenland. Medd. o. Grönland 74. No 11. Köbenhavn 1930.

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[1] Namnet »samider» (same = lappfolket) infördes efter beteckning av formationsgrupp på Kolahalvön (24).

18. Bütler, H., Some new investigations of the Devonian stratigraphy and tectonics of East Greenland. Medd. o. Grönland 103. No 2. Köbenhavn 1935.
19. Kranck, E. H., On the Crystalline Complex of Liverpool Land. Medd. o. Grönland 95. No 7. Köbenhavn 1936.
20. Bütler, H., Die Mächtigkeit der kaledonischen Molasse in Ostgrönland. Mitt. Naturforsch. Ges. Schaffhausen XV. 1935. 17.
21. Evans, I. W., and Stubblefield, Handbook of the geology of Great Britain. London 1929. 156.
22. Kolderup, C. F., Das Old Red in westlichen Norwegen. Fennia 50. No 23. Helsingfors 1928.
23. Wegmann, C. E., Preliminary report on the Caledonian orogeny in Christian X's Land. Medd. o. Grönland 103. No 3. Köbenhavn 1935.
24. Polkanov, A. A., Geological and Petrological Outlines of the NW-Part of the Kola Peninsula (på ryska). Leningrad-Moskva 1935. 564 s., 2 kartor.
25. —, A. A., Kotulski, W. K., och Maljawkin, S. F., Kola-halvöns problem (på ryska.) Leningrad 1933.
26. Magnusson, N. H., Om cykelindelningen i det svenska urberget. G. F. F. 58. 1936. 102.
27. Stille, H., Grundfragen der vergleichenden Tektonik. Berlin 1924.

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Artur Rindell.

IN MEMORIAM.

De flesta yngre medlemmar inom Geologiska Föreningen stå frågande inför detta namn. Han var dock medlem sedan 1897 och hans namn återkommer i medlemsförteckningen fram till 1930. I Föreningen, vid vars möten han under senaste årtionde ej varit synlig, uppträdde han endast en gång med diskussionsinlägg (1918) till ett föredrag av markgeologiskt innehåll.

Detta utesluter dock ej, att hans livsgärning varit av stor betydelse för fennoskandisk forskning på tvenne områden, som på det intimaste stå i kontakt med geologien.

Det ena området var markforskningen. Genom kemiska och mineralogiska studier vid Helsingfors universitet (1869—74), som lektor i kemi vid Mustiala lantbruksskola (1878) och genom kemiska specialstudier i Leipzig och Paris (1879—81) var han synnerligen väl införd i det kemiska underlaget för sitt senare forskningsfält. Som professor i agrikulturkemi och -fysik vid Helsingfors universitet (1900), som förste ordförande i dess agrikulturekonomiska sektion (1902) och som förste dekanus (1906) i samma universitets lantbruksekonomiska fakultet nedlade han ett outtröttligt arbete på organisationen och utvecklingen av den lantbruksvetenskapliga undervisningen. I samband härmed var han försöksledare i Finska Mosskulturföreningen, som han organiserat 1902 och i vilken han sedan 1906 var ordförande. Han var en tid ordförande i Nordiska jordbruksforskares förening och ständig ordförande i dess Finlands-avdelning. Han lyckades således på ett tidigt stadium i sitt hemland knyta jordbruks- och markforskning vid en centralinstitution: universitetet. På talrika resor fram och åter inom Skandinavien uppträdde han som den energiske förkämpen för nordisk markforskning.

Det andra området var geologisk forskning och undervisning. Som medlem i det utskott, som hade till uppgift att planlägga Åbo Akademi, påpekade han lämpligheten av att bland de första professurer, som tillskapades vid Akademien, även det geologisk-mineralogiska läro- och forskningsområdet var representerat. Som vicekansler för Akademien sedan dess start (1919) kunde han göra sitt inflytande gällande i den riktning att Akademiens Mineralogisk-geologiska Institution från första början och i fortsättningen blev jämförelsevis väl utrustad med utrymmen, instrumentarium och handbibliotek. Han lade sitt inflytande i vågskålen för tillskapandet av en ny geologisk-mineralogisk forskningshärd inom Fennoskandia. Hans privata mineralsamling (särsk. Tammela) är numera inom institutionen bl. a. ett vackert bevis på hans personliga omsorg för denna forskningsgren.

Artur Rindell var född i Åbo $^1/_{10}$ 1852. Han avled i sin födelse- och hemstad $^{21}/_1$ 1936. Som personlighet var Rindell den oföränderlige optimisten, ständigt redo till uppmuntran, ständigt beredd att bidraga till skingrandet av dysterhet inför svåra situationer. Som ledande forskare inom sitt fack i sitt hemland företrädde han ståndpunkten: utåt höra vi till Norden och förhandla på svenska, hemma bör var och en språkligt uppträda som det är honom och hans intressenter bekvämast. I uppträdandet i övrigt var han försynt och tillbakadragen, framhävde sist av allt sin egen personlighet.

H. G. Backlund.

Notis.

Några synpunkter på Leptaenakalkens bildningssätt.[1]

Av

BERTIL E. HALDEN.

Den härskande och förf. veterligen av ingen forskare i senare tid motsagda teorien, att Dalarnas Leptaenakalk uppstått som revbildning, äger ett visst stöd i den omständigheten, att analoga bildningar inom skilda geologiska formationer jorden runt tämligen allmänt betraktas såsom revbildningar.

Revteorien sådan den ganska enhälligt uppfattas i enlighet med J. WALTHERS definition av år 1893—94 (Einleitung in die Geologie) förutsätter främst av allt påvisandet av revbildande organismer in situ. Endast härigenom kan det geologiska revbegreppet hållas skilt från avlagringar av t. ex. skalbankarnas natur. En viss benägenhet till eftergift i detta hänseende ävensom den erfarenheten, att ett stort antal nutida tropiska »rev» jämte fossila motsvarigheter uppbyggas huvudsakligen av kalkalger (bl. a. lithothamnier) är säkerligen en av huvudorsakerna till den existerande enorma, alltjämt växande litteraturen om revbildningar (se t. ex. W. M. DAVIS, The Coral Reef Problem, 1928, samt några i det följande omtalade sammanfattningar). I den stratigrafiska litteraturen möter ej sällan benämningen »skiktade rev». Detta är enligt CUMINGS,[2] som skarpt hävdar de genetiska principerna, »a curiously inconsistent term, since a typical reef is by its very nature a non-bedded structure».

Vad Dalarnas Leptaenakalk beträffar, äro koraller visserligen anträffade, dock inga egentligen revbildande sådana. Kalkalger uppgivas även, men deras kvantitativa och revbildande roll inom Leptaenakalken synes ännu ej vara fullt utredd. (I nutida revbildningar ingå som bekant kalkalger jämte åtskilliga andra organismer särskilt i utfyllningarna av lagunerna innanför de autoktona revkammarna.)

Tanken på att krinoider svara för revbildningen i Leptaenakalken ligger tydligtvis nära till hands. Frågan är emellertid, om icke flertalet av de stjälkfragment, som omtalas från Leptaenakalken, i själva verket härröra från »armlösa» och sålunda näppeligen revbildande pelmatozoer, då ju »kulor»

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[1] Dessa synpunkter framhöllos i största korthet vid en akademisk provföreläsning »Silurformationen i Dalarna» i Uppsala den 17 januari 1936 samt i form av diskussionsinlägg vid Fil. lic. P. THORSLUNDS föredrag i Geologiska Föreningen den 5 mars d. å.: »Några stratigrafiska och tektoniska rön från Siljansområdet».

[2] CUMINGS, E. R., 1932. Reefs or Bioherms? — Bull. of the Geolog. Soc. of America. Vol. 43. — För bekantskapen med denna avhandling har jag Fil. lic. THORSLUND (muntligt meddelande efter marsföredraget) att tacka.

(kalkar) av cystidéer anträffats massvis, vilket icke synes vara fallet med krinoidkronorna.

Ett högst betydelsefullt faktum är, att bland de forskare, som yttrat sig om Leptaenakalken, ännu ingen kunnat eller velat genom att angiva revbildaren så att säga stå för revteorien.

Det bör dock i detta sammanhang erinras om en intressant uppgift av O. Isberg (G. F. F. 1917, sid. 225) rörande en ev. revbildare. Fyndets verkliga natur och därmed dess revbildande förmåga är emellertid mig veterligt ännu icke klarlagd.

Vill man utan förutfattad mening söka förstå Leptaenakalkens natur, är det nödvändigt att så allsidigt som möjligt söka rekonstruera bergartens tektonik, struktur, textur och andra petrografiska detaljer. De under senaste åren publicerade viktiga iakttagelserna på dessa områden ha föranlett förf. att betrakta Leptaenakalken från en mer dynamisk-geologisk synvinkel än den som vanligen anlägges i de framför allt paleontologiskt-stratigrafiskt betonade publikationerna rörande analoga bildningar. De faunistiska och stratigrafiska utredningarna äro visserligen oundgängligt nödvändiga, i viss mån primära förutsättningar för diskussionen av de genetiska problemen. De kunna dock icke ensamma räcka till för detta ändamål.

Förutom ovan framhållna brist på säkra revbildare förtjäna särskilt nedanstående synpunkter på Leptaenakalken att uppmärksammas:

1) Kalkens struktur. Under det att centralpartierna av kalkförekomsterna vanligen äro oskiktade, finner man i kanterna en tydlig skiktning och växellagring med andra sedimentformer. Detta av flera forskare skarpt pointerade drag hos Leptaenakalken är gemensamt för revbildningar (korall- och spongierev t. ex.) och skalbankar (för de senares växellagring med leror kan hänvisas till Halden, S. G. U. Ser. C. 280, Tavl. I, Finntjärn och Smälskmyren).

Revbildningarnas karaktär av att i centraldelarna vara oskiktade men mot kanterna övergå i skiktade bildningar (ty. Übergussmassen, uppvisande Überguss-Schichtung) har sin motsvarighet även i västkustens senglaciala skalbankar (Halden G. F. F. 1920, sid. 229). Att dessa skiktade kappor kunna uppvisa helt eller väsentligt annan fauna än centraldelarna har påvisats av G. De Geer (G. F. F. 1910, sid. 35, 37—39). Man jämföre härmed även de glaciala rullstensåsarnas ofta otydligt skiktade »kärna» med dess intimt anslutna, tydligare skiktade »skal», som kan innehålla postglaciala mollusker (se t. ex. A. Erdmann, Sveriges qvartära bildningar, figg. sid. 94, 95 och 102). Förf. tänker sig därför möjligheten, att Leptaenakalkens skiktade kantpartier delvis kunna innesluta en något yngre fauna än kärnan. En annan möjlighet, som i vissa fall kan tänkas leda till liknande uppdelning i faunistiskt hänseende mellan »kärna» och »skal», antydes av Isbergs (G. F. F. 1917), Haddings (Lunds Universitets årsskrift 1927 sid. 33) och Thorslunds m. fl. uppgifter om att cystidéer och pelmatozostjälkfragment äro vanliga endast i kantpartierna och där t. o. m. kunna förekomma massvis. Detta leder tanken till en primär, mekaniskt utförd fördelning av elementen i den zoogena kalkavlagringen. I samma riktning tala de av Warburg (G. F. F. 1910, s. 434) omnämnda massförekomsterna av trilobiter i Leptaenakalken, en fördelning, som har en viss motsvarighet i de senglaciala skalbankarnas »*Balanus*-grus».

2) Med avseende på fossilens bevaringstillstånd måste man, såsom ofta framhållits av revforskare, alltid räkna med betydande diagenetiska processer. En intressant detalj omtalas av ISBERG (1934, sid. 383), nämligen att musselskal och stenkärnor äro bättre bevarade i kalkbergen än i omgivande stratigrafiskt ekvivalenta sediment. Denna iakttagelse har sin direkta motsvarighet exempelvis i postglaciala *Mytilus*-bankar och därtill anslutna leror, i vilka senare stundom endast de mot kemisk upplösning resistenta epidermisfragmenten återstå (jfr t. ex. S. G. U. Ser. C. 280, sid. 181).

3) I fråga om Leptaenakalkens mäktighet har det genom THORSLUNDS år 1935 publicerade mätningar framgått, att de yngre »reven» (Bodakalken) vida överträffa de äldre (Kullsbergskalken). Sett i samband med nämnde forskares vid marsföredraget framhållna erfarenhet, att ceratopyge-ledets mot S i »silurringen» högst obetydliga mäktighet tydligt tilltager, ehuru med avsevärda växlingar, mot norr, kunde denna omständighet anses tyda på en tidigt begynnande och småningom skärpt reliefbildning i de ordoviKiska — gammalgotlandiska land- och bottenkonturerna inom en del av Dalarnas »silurring», där Leptaenakalk finnes anstående.

4) De genom särskilt ISBERGS, THORSLUNDS och WARBURGS omfattande arbeten påvisade radikala olikheterna i faunistiskt hänseende mellan Kullsbergskalk och Bodakalk, vilka båda olikåldriga kalkbildningar i terrängen kunna ligga helt nära varandra, utvisa, att gynnsamma yttre bildningsbetingelser för Leptaenakalk existerat under lång tid. Jämförelsen med våra västskandinaviska kvartära förhållanden ligger återigen nära till hands, då man vet, att såväl glaciala som postglaciala skalbankar där äro vanliga på samma trakt, närmare bestämt där terrängen är bruten, för att åter upphöra i den flackare terrängen S om Varbergstrakten (G. F. F. 1920, sid. 229).

5) Den del av »silurringen», där Leptaenakalken förekommer, innesluter bl. a. det område, där tektoniken av ålder betecknats såsom den mest förvirrade, t. ex. Bodatrakten. Detta i förening med den omständigheten, att Leptaenakalken själv är rik på sprickor etc. samt företer veritabla överskjutningar, dokumenterar området såsom ett utpräglat tektoniskt svaghetsområde.

Förkastningarna anses i allmänhet på goda grunder vara postsiluriska. Att betydande diastrofiska rörelser, möjligtvis med karaktär av det förkastningar, försiggått redan i ordovicium och äldre gotlandium framgår bl. a. av vissa märkliga sedimentpetrografiska lokalfacies inom det ifrågavarande tektoniska svaghetsområdet. Härmed förhåller sig i korthet på följande sätt:

6) Kalksandstenen, vars fältsamhörighet med Leptaenakalken påpekades åtminstone så tidigt som 1884 (av M. STOLPE), har en betydande utbredning särskilt inom Enådalen i Rättvik. Dess stratigrafiska ställning är emellertid på grund av fossilfattigdom ej närmare klarlagd. Ett viktigt undantag utgör den s. k. klingkalken, som genom THORSLUNDS undersökning visats vara en kalksandsten, ekvivalerande en del av Bodakalken. Kalksandstenen förutsätter ganska otvivelaktigt på grund av sin kvartshalt denudation av äldre silikatisk berggrund. En tänkbar möjlighet, som dock knappast torde kunna ledas i bevis, är att kvartshalten härrör från den i höjning stadda »urbergskupolen» innanför den stora silurringen.

En annan välbekant, betydligt äldre lokalfaciesbildning är den s. k. masurkalken (»knyckelkalken»). Denna är samtidig med övre delen av Kullsbergskalken. Möjligtvis utgör masurkalken ett kalkkonglomerat, vars fossilbrist kan tänkas bero på att dess ursprung ej är att söka inom Leptaenakalk utan från andra kalksediment. Detta kunde då möjligen anses tyda på att de diastrofiska förändringarna vid ifrågavarande tid ännu ej medfört en denudation av den äldsta berggrunden.

A. G. HÖGBOM (Bull. Ups. 1916, sid. 407) har från andra mellansvenska silurområden framhållit det sannolika samband som råder mellan vissa petrografiska sedimentfacies och förkastningarnas ålder, närmare bestämt att dessa faciesbildningar kunna anses såsom sannolikhetsbevis för att förkastningarna icke i sin helhet äro postsiluriska! De av HADDING och THORSLUND påbörjade sedimentpetrografiska undersökningarna av Dalasiluren kunna förväntas i fortsättningen lämna nya bidrag till bedömandet av relief-förhållandena under Leptaenakalkens bildningstid.

Skalbankshypotesens tillämplighet på här diskuterade bildningar är i hög grad beroende av ett riktigt bedömande av de dåtida reliefförhållandena. Att flera sannolikhetsbevis för brutna terrängförhållanden kunna andragas, framgår av det föregående. Kravet på en sådan terrängtyp grundar sig framför allt på erfarenheterna från de kvartära skalbankarna. Hänvisas bör här särskilt till förf:s uttalanden (S. G. U. Ser C. 280, sid. 182; G. F. F. 1920, sid. 228: »att de baltiska skalbankarna så gott som undantagslöst uppträda på sluttningen av eller i sänkor omedelbart nedanför berg, åsar etc.»), till R. SANDEGREN (Göteborgstraktens geologi, 1924, sid. 161 och S. G. U. Ser. Aa. N:o 173, 1931, sid. 78—81) ävensom till G. DE GEERS kartframställning (G. F. F. 1910, fig. 7 och pl. 43).

Vad själva sedimentationssättet beträffar, har förf. om skalbankarna framhållit, att deras element äro »nedfallna eller nedspolade» (S. G. U. ser. C. 280, sid. 182), varvid särskilt kärnan kan »uppfattas såsom ett på djupt och relativt lugnt vatten avsatt alloktont sediment» (G. F. F. 1920, sid. 229). Att skalbankarna allmännast anträffas på höjdernas läsidor (HALDEN S. G. U. Ser. C. 307, sid. 24) visar också, att vattenrörelserna vid tiden för skalgrusanhopningen ej varit allt för häftiga. Detta moment bör särskilt observeras, alldenstund motståndare till alloktonteorien gärna framhålla förekomsten av t. ex. musslor med båda skalen bibehållna i ursprungligt läge såsom något orimligt, därest materialet undergått häftiga rörelser av vågor etc.

Vid fullföljandet av de paleontologiskt-stratigrafiska undersökningarna av Leptaenakalken borde enligt det föregående särskild uppmärksamhet ägnas fossilenheternas storleks- och frekvensförhållanden i olika delar av en och samma förekomst (»rev»). Ett värdefullt uppslag i detta hänseende finnes i G. DE GEERS västsvenska skalbanksundersökningar (G. F. F. 1910), där tabellen upptager de olika arternas såväl individantal som vikt pr volymsenhet av skalgrusmaterialet. Genom dessa måttuppgifter blev det förf. möjligt att i vissa fall kunna bedöma enheternas »lättrörlighet» (G. F. F. 1920, sid. 229—230), en egenskap som f. ö. vore värd att experimentellt undersökas.

Om man från de synpunkter, som ovan andragits, mönstrar de på andra orter förekommande ordovikiska-gotlandiska bildningar, som särskilt ur stratigrafisk men även stundom genetisk synpunkt av åtskilliga forskare

(t. ex. TÖRNQUIST, WIMAN och WARBURG) anses ekvivalera Leptaenakalken, har man särskilt att fästa sig vid de ostbaltiska etagerna (»skikten»), vanligen kallade Lyckholm (F_1) och Borkholm (F_2). Om dessa ger den föreliggande litteraturen vid handen, dels att hela mäktigheten är mindre betydande (sammanlagt c:a 20 meter), dels att åtskilliga av de här förekommande »reven» äro skiktade. Sistnämnda egenskap karakteriserar likaledes den av engelska geologer som revbildning uppfattade »Chair of Kildare» på Irland, som emellertid når c:a 220 m mäktighet och genomsättes av andesit. Även Englands »Keisley Limestone» har att uppvisa »skiktade rev», delvis starkt dislocerade; såsom en ekvivalent faciesbildning omtalas en »hourny limestone». Något säkert stöd för revteoriens tillämplighet på de nämnda bildningarna har jag av den genomgångna litteraturen icke kunnat finna.

Av de yngre formationerna tilldraga sig särskilt de i allmänhet som revbildningar skildrade triadiska Dolomiterna i Tyrolen uppmärksamheten vid en jämförelse från de angivna synpunkterna. Man finner, att en grundlig utredning i detta hänseende redan föreligger. Enligt den av CUMINGS (se s. 359 noten) givna framställningen har det genom ett livslångt arbete av MARIA OGILVIE-GORDON blivit klarlagt, att de stundom mer än 3,000 fot mäktiga bildningarna, bestående huvudsakligen av kalkalger, utgöra enorma lagunutfyllningar bakom obetydliga barriärer av korall- och echinodermrev. CUMINGS säger därför (sid. 342): »The best recent students of the Dolomites refuse to call them reefs.» Detta omdöme förefaller dock väl hårt, alldenstund ju dock det autoktona »stödet» för de biogena kalkmassorna påvisats.

Från juran äro särskilt de bajerska spongiereven av intresse. Beskrivningen av dessa (t. ex. P. DORN, Untersuch. über fränkische Schwammriffe. Abh. d. Geolog. Landesuntersuch. am Bayerisch. Oberbergamt, München 1932) ger vid handen, dels att de förete skiktstrukturer, dels att vissa »rev» bestå av idel dvärgformer av olika djurgrupper (t. ex. småväxta brakiopoder, gastropoder, ammoniter och belemniter, fragment av echinider) eller t. ex. att ammoniter äro vanliga i de trågformade »normalsedimenten» i revens omedelbara närhet men däremot saknas i de övriga stratigrafiska ekvivalenterna. De anförda dragen tala starkt för mekaniska faktorers dominerande inflytande på bildningen av ifrågavarande »rev».

Inom kritformationen har man bl. a. att jämföra den cenomana »Klippenfazies» i Böhmen och Sachsen. I Sachsen består den av grovkorniga konglomerat, musselbreccior och märgelkalksten, bildande utfyllningar i underlagets fördjupningar. De böhmiska motsvarigheterna äga ett liknande uppträdande, då de nämligen förekomma exempelvis i djupa, breda sund eller i smala »fickor» i den äldre berggrunden. Även här dominera kalk- och konglomeratfacies. Revkalk angives särskilt, och man synes lägga stor vikt vid att de ingående arterna i allmänhet äro sessila. Sistnämnda moment är dock numera föga ägnat att stödja uppfattningen om att rev föreligga, då ju våra svenska, av flertalet forskare såsom alloktona uppfattade kvartära skalbankar kunna få sin prägel just av sessila former sådana som *Mytilus edulis* och balanider. Av visst intresse för jämförelsen med Leptaenakalken är uppgiften om kalkkonglomerat, som äro inskjutna i de böhmiska »reven», ävensom existensen av en hård, tät kalksandsten i Böhmens »Klippenfazies», samt att man på endast några få km från »Klippenfazies» anträffar »lugn sandstensformation». (Se t. ex. SCHANDER, Zeitschr. d. deutschen Geolog. Gesellsch. Bd 75, 1923.)

Lundegren har i sin gradualavhandling (G. F. F. 1934) pointerat den morfologiska och genetiska överensstämmelsen mellan nämnda »Klippenfazies» och NO-Skånes kritbildningar och för de senares genetiska ställning hänvisat till den alloktona strukturbild, som våra senglaciala skalbankar förete. Till denna jämförelse vill jag endast foga den kompletterande uppgiften, att den skånska kretaceiska »skalstoftkalken» äger sin klara motsvarighet hos de kvartära skalbankarna. Här åsyftas de mer eller mindre leriga distala fortsättningar — »mikrostruerade skalbankar» — som förf. skildrat (G. F. F. 1925, sid. 122). Detta är emellertid icke något mer betydande argument vare sig för eller emot revteorien, alldenstund även från korallreven omtalas »korallslam» etc. Som en motsvarighet härtill kan man emellertid beträffande äldre, diagenetiskt förändrade bildningar mycket väl uppfatta vissa kalksandstenar och märgelstenar.

Jämförelsen mellan revbildningar och skalbankarna ger sålunda vid handen, att det långt ifrån alltid är lätt att draga gränsen mellan båda. Huvudorsaken härtill torde vara den rikliga förekomsten av alloktont material i bådadera bildningarna. Den väsentligaste skillnaden är otvivelaktigt, att stödet för de mer eller mindre tydligt skiktade sedimentanhopningarna i skalbankarna — här bortses från bildningar av ostronbankarnas natur — utgöres av klippor eller jordhöjder, medan de äkta reven äga av autoktont biogent material uppbyggda, bränningsfasta vallar eller barriärer.

Med avseende på Leptaenakalkens ursprung må sålunda sammanfattningsvis framhållas:

att revteorien ställer oavvisliga krav på att själva revbildaren påvisas;

att Leptaenakalken visat sig äga en struktur, som i många hänseenden påfallande överensstämmer med de kvartära skalbankarnas;

att den terräng, vari Leptaenakalken uppstått, med största sannolikhet varit bruten redan vid tiden för de äldsta revens uppkomst.

Jag betvivlar ingalunda möjligheten att »revbildaren» åtminstone för en del av förekomsterna skall komma att i en framtid påvisas. Intill dess att detta sker måste jag dock göra gällande, att »skalbanksteorien» förtjänar att ställas i full paritet med revteorien.

Anmälanden och kritiker.

Isavsmältningen i Bergslagen.

En prioritetsfråga.

Av

E. Ingmar.

I en uppsats i[1] Geol. Fören. Förhandl. har Statsgeologen Dr G. Lundqvist lämnat några preliminära meddelanden om sina undersökningar över isavsmältningen i Bergslagen.

Utgående från en allmän lutning av 1 : 550 för landisen kommer Lundqvist till det resultatet, att då landisen i Vessman-bäckenet var 100 m mäktig, hade den i Siljan-bäckenet en mäktighet av 200, i Amungen 175 och i trakten av Runn 150 m. En följd av dessa lutnings- och avsmältningsförhållanden hos istäcket skullle enligt Lundqvist bli, att Västerdalälvens dalgång tidigt blev isfri.

Innan Lundqvist kunnat tillämpa sin avsmältningshypotes på denna trakt, har han emellertid varit tvungen att avlägsna betydande hinder. Det av[2] Magnusson påvisade vackra ändmoränstråket från Nyed i Värmland upp till trakten V om Malung måste enligt Lundqvists eget medgivande förutsätta, dels att landisen i dessa trakter varit levande under avsmältningen, dels att istäcket varit relativt mäktigt. Hur skola dessa handgripliga fakta kunna förenas med den Lundqvistska avsmältningshypotesen, som kräver, att trakten tidigt måste ha blivit isfri? Jag citerar[3] Lundqvist, som löser det svåra problemet lekande lätt: »Därför uppstår frågan, hur vi skola få bort detta (det mäktiga istäcket) successivt utan att bryta mot de tidigare premisserna om ytavsmältningen. Därför erfordras nämligen här ett större vattendjup, än den vanligen antagna M. G. möjliggör. Måhända ligger förklaringen i de då och då uppdykande uppgifterna om abnormt höga M. G.-värden i dessa trakter.»

För den, som känner Lundqvists tidigare nyktra och realistiska syn på M. G.-problemet och vet, att Lundqvist genom sina egna M. G.-undersökningar i Bergslagen bidragit till att grusa alla »höga funderingar» på M. G. i dessa trakter, förefaller Lundqvists gripande efter höga M. G.-värden i Värmland något egendomligt, för att ej säga misstänkt. Lundqvists avsmältningshypotes måste tydligen kunna tillämpas på trakterna kring Västerdalälvens dalgång, så att denna tidigt må kunna bli isfri. Om något otrevligt, mäktigt istäcke enligt av andra forskare framlagda ofrånkomliga fakta måste ha funnits, så måste detta undanskaffas, på det att det ej må komma i vägen för den Lundqvistska avsmältningsmekaniken. Därför höjer Lundqvist ishavet, för att dess vågor må kunna smälta och bräcka sönder det besvärliga istäcket!

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[1] G. Lundqvist, Isavsmältningen i Bergslagen. G. F. F. Bd 57, s. 287—301.

[2] Nils H. Magnusson, Beskrivning till kartbladet Nyed. Sv. Geol. Unders. Ser. Aa, N:o 144.

[3] G. Lundqvist, Ovan anf. arb. s. 291.

Om man noggrant läser igenom LUNDQVISTS ovan anförda uppsats och därvid särskilt lägger märke till LUNDQVISTS citat och litteraturanvisningar, så finner man snart, var den verkliga och bärande grunden till LUNDQVISTS uppfattning om den tidiga avsmältningen av Västerdalälvens dalgång är att söka. LUNDQVIST citerar noggrant andra forskare, som arbetat i de periferiska delarna av hans arbetsområde, såsom G. FRÖDIN och E. TEILING, och en stor mängd andra glacialgeologiska forskares arbeten, inalles över ett trettiotal, men beträffande den forskare, som sedan ett flertal år tillbaka arbetat just med isavsmältningen i Bergslagen och Västerdalälvens dalgång, nämligen undertecknad, iakttager LUNDQVIST en talande tystnad.

Genom mina undersökningar somrarna 1926 och 1927 blev det klart för mig, att en stor issjö måste ha funnits i Västeradlälvens dalgång. Huvuddragen av de då vunna resultaten framlade jag våren 1931 i en[1] uppsats, som jag samma vår tillsände LUNDQVIST, och för vilken han sedan genom ett kort tackade. Då jag måste antaga, att D:r LUNDQVIST genomläser den facklitteratur, han får sig tillsänd, i all synnerhet sådan litteratur, som berör hans eget arbetsområde, så synes mig LUNDQVISTS ihjältigande av mitt utförda arbete synnerligen egendomligt. Visserligen kan LUNDQVIST invända, att jag i ovan anförda uppsats ej angivit, hur långt Västerdalälvenissjön sträckt sig mot N och NV inom Dala-Järna, Äppelbo och Ytter-Malungs socknar, men jag har dock angivit issjöns alla viktigare avlopp: vid Lindesnäs, Svanberget, Birtjärnsberget och V om Tansen, ävensom det slutliga avtappningsavloppet vid Björka i Gagnefs socken. Dessutom har jag omnämnt talrika mot trösklarna korresponderande strandmärken och på en kartskiss angivit, att issjön sträckte sig från Björka i Gagnefs socken till trakterna SV om Vansbro vid Eldforsen och Tretjärns station. Att issjön sannolikt sträckt sig längre mot N har också antytts på skissen, och till slut har jag, så gott det varit möjligt på den lilla skissen, utmärkt den ganska stora issjö, som funnits i de södra delarna av Äppelbo socken.

Dessutom vill jag framhålla, att jag redan året innan jag lät publicera förut omnämnda uppsats (Icedammed lakes etc.) under min korrespondens med LUNDQVIST för honom omnämnde, att jag arbetat med issjöar även i Västerdalälvens dalgång. Att LUNDQVIST rätt uppfattat mina meddelanden, framgår av vår korrespondens.

Somrarna 1931 och 1932 fastställde jag exakt issjöns utbredning i Dala-Floda och Dala-Järna socknars norra del och fann då, att issjön sträckt sig avsevärt längre mot N., än jag av mina tidigare undersökningar kunnat förmoda, och att issjön även i N haft moränstränder så gott som överallt inom dessa områden. Sommaren 1933 kunde jag tack vare understöd från Sällskapet för antropologi och geografi och från Längmanska kulturfonden undersöka issjöns västra och nordvästra delar i Äppelbo och Ytter-Malungs socknar, över vilka undersökningar jag inlämnade rapport till Sällskapets styrelse samma höst. Dessutom har jag genom ett flertal samtal med Prof. J. FRÖDIN och Doc. G. FRÖDIN i Uppsala hållit dessa fackmän à jour med mitt arbetes fortgång.

Huvuddragen av mitt arbete med isavsmältningen inom Västerdalälvens dalgång måste således ha varit känt av LUNDQVIST, och det slutliga resultatet av mitt arbete har genom ett flertal stipendieansökningar, reseberättelser och samtal under hand varit känt av ett flertal forskare både i Stockholm och Uppsala, långt innan Lundqvist skrivit sin ovan anförda uppsats om isavsmältningen i Bergslagen. Dessutom vill jag framhålla, att jag på eget initiativ börjat och slutfört mitt arbete med issjöbildningarna och isrecessionen inom Västerdalälvens dalgång, samt att till dess jag sommaren 1933 hade slutfört dem, ej en rad publicerats om hithörande frågor, frånsett mina egna preliminära meddelanden. Jag har således självständigt och före någon annan visat, att i Västerdalälvens dalgång från Björka i Gagnef till Edet och Örarbäcken i Ytter-Malungs socken funnits en omkring 7 mil lång isdämd sjö, som uppdämts av en från Siljan-bäckenet längs Österdalälvens dalgång nedskjutande istunga. Och likväl låtsar Lundqvist, som om jag och mina undersökningar ej funnes till.

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[1] ERNST INGMAR, Icedammed lakes and the marine limit in the north of Västmanland and the south of Dalecarlia. Bull. of the Geol. Inst. of Upsala, Vol. XXIII.

Lundqvists beteende är i sanning kostligt: När jag genom på empirisk väg vunna fakta fastslagit, att en stor issjö måste ha funnits i Västerdalälvens dalgång, kommer Lundqvist långt efter och försöker genom långa hypoteser och deduceringar bevisa, att trakten kring Västerdalälven måste ha varit isfri tidigare än de SO därom liggande trakterna. Sådant kallar man i dagligt tal »att slå in öppna dörrar».

Lundqvists tillvägagångssätt härvidlag är fullkomligt analogt med hans behandling av mina M. G.-undersökningar i Bergslagen:[1] Fastän jag långt före honom erhållit i det närmaste samma resultat som han, och fastän dessa mina arbetsresultat delvis äro publicerade, så ihjältiger Lundqvist konsekvent alla mina undersökningar och låtsar, som om han vore den förste, som hade vunnit ifrågavarande resultat. Om Lundqvist tror sig i längden vinna någon vetenskaplig ära och berömmelse genom sådana metoder, så misstager han sig grundligt.

Beträffande det sakliga innehållet i Lundqvists uppsats om isavsmältningen i Bergslagen skall jag göra några anmärkningar.

De värden för istäckets mäktighet, som Lundqvist erhållit genom sin efter grönländska förhållanden konstruerade gradientmetod, äro bevisligen alldeles för låga. Genom iakttagelser och uppmätningar av issjöstrandlinjer och issjöavlopp från sydvästra delen av Siljanbäckenet har jag kunnat konstatera, att då isranden stod ungefär i trakten av Leksands-Noret, låg landisens yta i den sydvästra delen av Siljan-bäckenet omkring 200 m över Siljans nuvarande nivå. Då Siljan har ett djup av över 100 m, var isens mäktighet i de djupaste delarna avsevärt över 300 m. Det är tydligt, att då landisen i dessa trakter hade en sådan mäktighet vid en så sen tidpunkt, den vid den tid, då isranden stod i det 5—6 mil S om Leksand belägna Vessmanbäckenet, måste ha haft en betydligt större mäktighet, än Lundqvist angiver. Även från den västra delen av mitt arbetsområde, som faller inom Dala-Järna, Äppelbo och Ytter-Malungs socknar, kan man med hjälp av issjöstrandlinjer och issjöavtappningar visa, att landisen vid den av Lundqvist angivna tidpunkten måste haft en avsevärt större utbredning och mäktighet, än Lundqvist söker göra gällande. Likaså kan man med stöd av den stora Västerdalälven-issjöns strandlinjer visa, att isavsmältningen i dessa trakter i stort sett gått från SSO mot NNV och ej i rakt motsatt riktning, som Lundqvist med stöd av sin avsmältningshypotes söker hävda. Västerdalälvens strandlinjer, som stiga mot NV—NNV, ha nämligen nått sin största höjd i en linje 3—4 km SSO om Ytter-Malungs kapell och sänka sig från denna linje mot NNV. Detta torde knappast kunna tolkas på annat sätt, än att issjön, som nu hade börjat avtappas vid Björka i Gagnefs socken, nådde allt lägre nivåer med sin strandlinje, allteftersom isen avsmälte mot NNV. De glacifluviala avlagringarna visa samma tendens: Fastän berggrunden och moränunderlaget stiga mot NNV, sänka sig planåsarnas och deltanas ytor mot detta väderstreck för att alldeles kila ut och försvinna mellan Örarbäcken och Lugnet. På samma sätt har jag längre österut lyckats fastställa, att isranden vid issjöns begynnande avtappning stod över sydspetsen av Vansjön och ungefär 1 km S om St. Flaten. Isranden har således från de östra delarna av Dala-Järna till Ytter-Malung vid denna tidpunkt i stort sett haft en sträckning från ONO till VSV. Denna riktning för isranden är vinkelrät mot räfflorna i dessa trakter. Mellan Äppelbo och Ytter-Malung har jag uppmätt en stor mängd räfflor med en riktning N 8° V—N 30° V. Av dessa räfflor voro många så ytterst fina, att de kunde iakttagas endast vid lämplig belysning och sedan hällarna fuktats och borstats rena. Märkligt nog ha de allra finaste reporna den västligaste riktningen.

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[1] Se: G. Lundqvist, Bergslagens marina gräns. G. F. F. Bd 55; och E. Ingmar, Bergslagens marina gräns. En prioritetsfråga. G. F. F. Bd 56.

Nu kan givetvis LUNDQVIST från sin synpunkt invända, att dessa räfflor ej ha någon beviskraft, när det gäller israndens riktning under avsmältningen, då isen var död vid denna tidpunkt. Att stora döda ispartier funnits i Dalarna under landisens avsmältning, är uppenbart och kan konstateras både av moräntopografien och de glacifluviala erosionsfenomenen. Ett typiskt dödislandskap —[1] av LUNDQVIST antytt på hans kartskiss — är beläget N om sjöarna Flaten och Snesen. Det ligger i full överensstämmelse med ett sådant landskaps genesis omkring 200 m lägre och omedelbart S om Fjällbergets mäktiga höjdsträckning. Men även om dödispartier funnits här och var inom Dalarna, liksom på alla andra ställen, där topografiens relief varit tillräckligt skarp, så är därmed ej bevisat, att en jättelik dödis täckt större delen av Dalarna från den tidpunkt, då landisen i Vessman-bäckenet var 100 m mäktig.[2] LUNDQVIST söker stödja denna märkliga uppfattning med det ännu märkligare påståendet,[2] »att ändmoräner synas så gott som fullständigt saknas inom hela det supramarina området». Att LUNDQVIST kan göra ett sådant påstående, förvånar mig i hög grad, då jag flerstädes inom mitt arbetsområde iakttagit ändmoräner, på några ställen mycket mäktiga sådana. Så finnas t. ex. i södra delarna av Leksands socken mellan Flosjön och Sången fyra kraftiga, i Ö—V gående, nära kilometerlånga ändmoräner. De bestå av mycket grov morän, ha en typisk, brant distalsluttning och äro på sina ställen 13—15 m höga. I höjd med ändmoränerna och Ö om dessa ha rullstensavlagringarna, som i allmänhet äro av ganska ringa mäktighet i denna dal, bildat en kraftig ansvällning, varvid ett omkr. 600 m långt och 400 m brett kittel- och kameslandskap bildats. Ö om detta har en i ÖV gående, ännu mäktigare ändmorän bildats. Det kan här ej vara tal om någon lokal glaciation, utan en istunga har skjutit fram från Siljan-bäckenet genom Ejens och Sångens dalgång. Denna istunga måste ha haft en stor levande kraft ända ut i sina yttersta delar, då så mäktiga moränvallar kunnat hopskjutas, och avsmältningen måste här ha gått mycket långsamt, ja att döma av den östra ändmoränen måste ett avbrott i recessionen här ha ägt rum.

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[1] G. LUNDQVIST, Isavsmältningen inom Bergslagen. G. F. F. Bd 57, s. 298.
[2] G. LUNDQVIST, Ovan anf. arb. s. 297.

Jag kan ej här redogöra för alla de iakttagelser av ändmoräner, som jag gjort inom Västerdalälvens avvattningsområde, men jag vill i korthet nämna, att ändmoräner finnas vid Västerdalälven-issjöns avlopp VNV om Tansen och vid avloppet SO om Birtjärnsberget och flerstädes inom Dala-Järnabäckenet.

Att landisen i Siljan-bäckenet och S därom haft en stor levande kraft under avsmältningen framgår också av det faktum, att de issjöavtappningar, som ägt rum på moränåsarnas norra och nordvästra sluttningar, försiggått ytterst långsamt. Under den tid, Västerdalälven-issjön avtappades vid Björka, avsmälte isbrämet ej mer än omkring 60 m i vertikal riktning, och likväl har landet att döma av avloppsmynningarnas och M. G:s förskjutning hunnit höja sig omkr. 6 m. Samma fenomen kan iakttagas inom Hälgsjön-issjöns avtappningsområde vid Sätra i Åls socken, Yxen-issjöns vid Grytnäs i Leksands och vid Alvik i Siljansnäs socken och Ejen-issjöns vid Fårberget i Siljansnäs socken. Halden[1] har redan förut framhållit, att M. G. inom Siljansnäs socken visar mot N och NV sjunkande värden, och även om mina genom undersökningar av de marginala issjöavloppens mynningar och deltabildningar erhållna värden för M. G. skilja sig något från hans, så utvisa de dock samma tendens. Särskilt vid Alvik och Fårberget kan iakttagas, att isranden under avsmältningen med stor kraft stött mot sluttningen; vid Fårberget visar det av issjöavloppen tidigare avsatta gruset tydliga hopskjutningsfenomen.

Slutligen vill jag framhålla, att förekomsten av mjäla i Västerdalälvens dalgång vid Malung ej är något bevis för att en isdämd sjö funnits i denna trakt.[2] Den stora Västerdalälven-issjön har, som förut nämnts, ej nått längre än till Örarbäcken, och NNV om Lugnet har funnits en normal senglacial sjö. Denna sjö har haft sin avloppströskel vid Lugnet, och därigenom att denna tröskel nederoderats, har sjön urtappats.

Svar på Mag. E. Ingmars prioritetsfråga.

Av

G. Lundqvist.

Mag. Ingmar har även i år använt underrubriken »En prioritetsfråga». Jag måste alltså utgå ifrån att den ömma punkten ligger just däri och icke i någon sakfråga. I hela den långa utredningen synes mig endast underlåtenheten att citera Ingmar för upptäckten av issjön vid Malung kunna inbjuda till en prioritetsdiskussion. Jag tror mig icke om att kunna klarlägga frågan för Ingmar, men om någon objektivt läst hans inlägg kan ju tänkas, att denne vill se även min syn på saken.

Ingmar kritiserar inledningsvis, att jag använt de höga M. G.-värdena i Vänerbäckenet. Min av Ingmar citerade försiktiga formulering torde dock icke kunna klandras. Mina åberopade egna »nyktra och realistiska» fälterfarenheter av M. G. äro nämligen icke hämtade ur Vänerbäckenet.

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[1] B. Halden, Föredrag om Siljanstraktens kvartärgeologi. G. F. F. Bd 55.

[2] G. Lundqvist, Förut anf. arb. s. 291.

Historien om issjön vid Malung är följande. I INGMARS tryckta uppsats 1931 slutar issjön på kartan (S. 199) strax S om Äppelbo, i texten (S. 198) finnes ingen antydan om, att den skulle ha nått upp till Malung; icke ens uttalandet: »The nothernmost limit of the last ice-lake stage has not yet been determined» kan jag tolka så. Hela kartbilden antyder, att INGMAR i princip tänkt sig en c:a O—V-lig isbräcka rakt över höjder och dalar.

Senare har INGMAR fortsatt sina arbeten, men hur långt mot N har jag icke vetat förrän SANDEGREN nu påpekat för mig, att en reseberättelse (28 rader) däröver finnes intagen i Ymer 1934 (S. 137). Där läses om issjön ifråga: »Issjöns nordvästligaste vik har funnits mellan Nordanåker och Örarbäcken i Ytter-Malung.» Detta är allt. Eftersom INGMAR även citerar vår korrespondens vill jag anföra hans intressanta »avslutningsbrev» av den 4. 1. 1932: »Förliden sommar fortsatte jag undersökningarna i Västerdalälvens dalgång och lyckades då konstatera, att den sista stora issjön i denna dalgång sträckt sig ända till Dala-Järna och Vansbro.» Förmodligen menas från Ö men i varje fall ligger området mer än 3 mil SO om Malung.

På dessa fakta utslungar nu INGMAR beskyllningen att jag orättmätigt sökt tillskansa mig någon vetenskaplig ära (!) på hans bekostnad. Insinuationerna, att jag fått kännedom om hans arbeten genom »stipendieansökningar, reseberättelser och samtal under hand . . .» kunna belysas av följande. Prof. J. FRÖDIN (och Mag. INGMAR) har jag aldrig råkat, Doc. G. FRÖDIN vet jag mig ej ha sett sedan 1919; jag är icke medlem av Svenska Sällskapet för Antropologi och Geografi och har därför ingen möjlighet att få se dit inkomna stipendieansökningar.

Det finns emellertid ett sakskäl, varpå jag grundade min uppfattning om att Västerdalälven varit dämd i S och det är helt enkelt, att jag för flera år sedan såg mjäla vid Malung, c:a 3 mil NV om Äppelbo och c:a 1 mil NV om INGMARS »nordvästligaste vik». En förekomst av issjöar inom stora delar av Västerdalälvens O—V-liga, alltså södra, del har jag däremot aldrig betvivlat eller behövt diskutera i sammanhanget. Prioriteten på dem har jag aldrig ens tänkt försöka tillskansa mig.

För att reducera INGMARS inlägg till dess rätta proportioner vill jag citera vad jag skrivit (S. 291): »De finkorniga sediment, mjäla etc., som anträffas så långt upp vid Västerdalälven som i Malung, alltså högt över M. G., få sålunda sin naturliga förklaring som issjösediment.» Att INGMAR nu tolkar förekomsten på annat sätt än jag, är en sak för sig.

Det väsentliga i min lilla uppsats var att tillämpa idén om landisens ytavsmältning inom huvudsakligen det supramarina området. Och för att undvika »prioritetsfrågor» sade jag ifrån, att denna idé icke var ny (detta mitt uttalande synes f. ö. ha förbisetts även av HALDEN i förra häftet av G. F. F.). Men däremot tror jag ej, att någon tidigare med en längdprofil genom landet granskat effekten av en sådan avsmältningsmekanik. Det hela var rent konstruktivt, vilket jag uttryckligen framhöll. Det väsentliga resultatet var, att de stora närområdena måste ha försvunnit oväntat tidigt. Att synpunkten icke bör negligeras finner man både vid nutida glaciärer och vid vanlig snösmältning, vilket f. ö. HALDEN (G. F. F. 1936, S. 109) påpassligt illustrerat. De avsmältningsförhållanden jag framhållit måste diskuteras, då de torde ha medfört en allmän utbredning av stora dödisar, vilka förorsakat uppdämning av bäcken öppna mot söder. Sådana dödisar utesluta icke issjöar, ty issjöarna behöva icke ha varit isfria mer än vid stränderna (jfr sedimentens utbredning och topografi). Det är dessa stora drag som äro av intresse, icke om en liten islob skjutit in i den ena eller andra dalgången. Detta är ju detaljer, vilka aldrig behöva dragas in i en principdiskussion.

Ovanstående synpunkter kan jag icke utläsa ur INGMARS skrifter. Det förefaller snarare, som om han hyser motsatt uppfattning. Och då kan väl icke talas om någon prioritet.

Slutligen: det kan visserligen vara bra att ha de sakliga upplysningar INGMAR här ovan publicerat. Men det förefaller mig dock som om forskningen skulle vara mera behjälpt av att få dem i ett sammanhang i stället för som »prioritetsfrågor» var gång jag skrivit en uppsats.

Svar till Dr G. Lundqvist.

Av

E. INGMAR.

Som svar på Dr G. LUNDQVISTS inlägg vill jag till honom rikta tvenne frågor: »Anser Ni, Dr LUNDQVIST, att det är i överensstämmelse med god vetenskaplig kutym att i ett vetenskapligt arbete citera alla andra forskare, som kunna komma i fråga, utom den, som arbetat med samma problem inom samma arbetsområde? Anser Ni, att en forskare, därför att han ger sig in på en principdiskussion om ett problem inom ett visst område, är befriad från skyldigheten att taga hänsyn till ett arbete, som utförts just inom detta område, i all synnerhet om detta arbete helt eller delvis löst det problem, varom principdiskussionen rör sig?»

Slutreplik till Mag. Ingmar.

Av

G. LUNDQVIST.

Beklagligtvis nödgas jag av ovanstående frågor för, som jag hoppas, sista gången taga G. F. F:s utrymme i anspråk för denna affär. I Mag. INGMARS uppsats 1931, sid. 194 läses: »With the direction which — according to the observations of striæ related above — the ice-movement took during the period of melting, the formation of large ice-dammed lakes was as a rule not possible, as most of the larges valleys open towards the south and the south-east.» Fritt översatt betyder detta, att vi ha grundväsentligt olika åsikter om principen för isavsmältningens förlopp. Det synes mig icke nödvändigt citera alla som ha en annan mening, icke ens om de råkat arbeta i en trakt något år tidigare än jag. Om INGMAR muntligen i Uppsala uttalat en annan åsikt än ovanstående känner jag ej. Jag vill dessutom tillägga öljande. Kvartärgeologien är en betydligt svårare vetenskap än många vilja tro. Orsaken därtill är, att vi här i regel sakna den kontroll av premisserna som t. ex. petrografien erbjuder. Därför kan en och samma företeelse ofta uppfattas på många olika sätt, och det kan icke av beskrivningen enbart — och än mindre av blotta påståendet — vara möjligt att avgöra,

om den är rätt tolkad. Erfarenheten har lärt mig, att man måste vara synnerligen försiktig även med kunniga yrkesgeologers uppgifter om skäligen elementära bildningar. Gäller det uppgifter om så subtila företeelser som t. ex. issjöstrandlinjer, kan man ej vara nog kritisk. Det kan därför icke hjälpas, att jag måste verka kritisk även gentemot Mag. INGMAR.

Bemerkungen zu der Mitteilung von Herrn Áskelsson.

Von

KONRAD KEILHACK, Berlin-Wilmersdorf.

Die Mitteilung des Herrn JÓHANNES ÁSKELSSON auf Seite 111—112 des 1. Heftes von Band 58 dieser Förhandlingar und die darin enthaltene Korrektur einer meiner auf der nordwestlichen Halbinsel Islands gemachten Beobachtungen über das Vorkommen von weissen Sanden, die ich vom Schiffe aus für Quarzdünen gehalten hatte, während die von Herrn Á. mitgeteilte Analyse zeigt, dass es sich um Kalksande handelt, hat mich auf das lebhafteste interessiert. Ich hatte mich, seit ich im Jahre 1924 jene Beobachtungen machte, verschiedentlich bemüht, Proben jener Sande zu erlangen, z. B. durch Schreiben an den Pfarrer einer in der Nähe einer der Sandstellen liegenden Kirche und durch Bitten um Proben an alle mir bekannten Islandfahrer der letzten 10 Jahre, aber alles war vergeblich. Nun ist ja die Frage, die mir viel Kopfzerbrechen gemacht hat, gelöst, wenn auch die Erklärung dieser Sande als koprogene Bildungen neue Schwierigkeiten bereitet und neue Fragen aufwirft.

Eine Bemerkung Herrn ÁSKELSSONS möchte ich berichtigen: es ist nicht ganz zutreffend, dass »die meisten Beobachtungen vom Deck des Schiffes auf der Reise längs der Küste der Westfjorde angestellt wurden»; das gilt nur für die Punkte 1—4 meines Aufsatzes. Für die Zählung der Basaltdecken, die Feststellung der Basaltgänge und die Lage der Kare ist ja eine Küstenfahrt die denkbar beste Gelegenheit. Im übrigen aber habe ich genügend Zeit und Gelegenheit gehabt, Landbeobachtungen zu machen, und zwar in Vatneyri im Patrekfjördr, bei Hildudalr im Arnarfjördr, bei Thingeyri im Dyrafjördr, bei Flateyri im Önundarfjördr und endlich drei Tage hinter einander, immer bei wolkenlosem Himmel und unvergleichlicher Durchsichtigkeit der Luft, in Isafjördr dem aufblühenden Haupthandelsplatz am Skutilsfjördr.

Ferner möchte ich bemerken, dass ich durchaus nicht festgestellt habe, wie Herr ÁSKELSSON schreibt, dass es sich hier um Quarzsande handelt, sondern dass ich nur als das wahrscheinlichste einen quarzigen Charakter dieser ausgedehnten weissen Dünenflächen angenommen habe. Der Gedanke an eine koprogene Entstehung solcher Sande war mir allerdings nicht gekommen.

De gästrikländska fornstrandlinjerna.

Av

B. Asklund.

I sistutkomna häfte av denna tidskrift har Lektor B. Halden i uppsatsen »Isavsmältning och strandförskjutning i Siljansdalen», s. 76—78, framfört några kritiserande inlägg mot mitt arbete om de gästrikländska fornstrandlinjerna. Då Halden själv uppger sig icke haft tillfälle att vid tiden för sin uppsats tryckläggning tränga djupare in i min framställning äro måhända de synpunkter jag här framför och upprepar från min skrift obehövliga som bemötanden, men de synas mig å andra sidan kunna främja diskussionen kring de problem, som intressera oss bägge.

Beträffande expositionsriktningarna måste jag först beriktiga Haldens uppgift, att jag skulle ha framhållit att vågskydd även skulle tillkomma de mot söder vettande, äldsta fornkustpartier. Så är icke förhållandet. Detta kan också belysas med Sandegrens karta, fig. 20, i beskrivningen till kartbladet Storvik, fördelningen av land och vatten vid olika nivåers utbildning. Expositionerna för nordliga och sydliga vindar är såsom jag framhåller å sid. 39 i mitt arbete alldeles likartade. Oaktat att de högsta strandmärkena saknas på många nordsluttningar pa grund av dödisförekomsternas sannolikt största frekvens i dessa lägen (troligen beroende på nordsidornas skuggläget) uppvisa likväl dessa, när dödisar icke stört strandlinjernas normala inregistrering, ett markerat maximum i 195-m:s-läget (jfr sid. 37, fig. 22), medan samtidigt den mest framträdande expositionsriktningen, den östliga, visar mycket ringa strandmärkesfrekvens och den sydliga, vid avsmältningen gynnade expositionsriktningen, saknar detta maximum. Den vid denna tid ännu obetydligt vågskyddade västriktningen saknar alldeles strandmärken. Dessa omständigheter tala tydligt till förmån för oliktidig dominans för olika vindriktningar. Att tillskriva dessa olika förhållanden morfologiska omständigheter synes mig vara att lämna problemets kärna oberörd.

Under landhöjningsskedet 200—160 m var som förutnämnda illustration av Sandegren ger upplysning om den ostliga expositionen mycket oväsentligt mera framträdande än nord- och sydexpositionerna. Den starkast framträdande abrasionen i nordostriktningen, började vid 185 m:s nivån, är dokumenterad med kalhällarnas maximifrekvens i denna riktning, klapperstenarnas maximala storlek och strandvallarnas starka destruktion i bränningszonen. Vid studiet av området äro dessa så övertygande drag, att varje granskare i fältet torde kunna verifiera min tolknings betydelse.

Vägsträckan för vågens framförande har jag förvisso icke lämnat obeaktad (jfr beskrivningen till kartbladet Storvik sid. 105, upptill) men i huvudsak inrymt i begreppet exposition. Emellertid vill jag understryka, att denna faktor för de äldsta landhöjningsskedena äger mindre betydelse, då nämligen vid denna tid andra för strandmärkenas utdaning gynnande faktorer spelat mera framträdande roll. En sådan är bristen på ett skyddande växttäcke och rotbunden mark på de med finjordsrika moränjordar höljda bergkullarna, en annan och som jag utförligt uppehållit mig vid är isfotbildningen, som delvis varit av dominerande betydelse och ännu ned till Ancylusgränsens höjd förmått dana verkliga erosionshak i fast berg, företeelser som i övrigt icke synas ha utförligare belysts från norrländska kustområdets äldre strandlinjenivåer, men där säkerligen spela en icke oviktig roll.

Haldens kritik mot min intensitetsgraderingsmetod synes mig onödigt negativ. Det har för mig gällt att vinna ett objektivare uttrycksmedel för framställningen om strandlinjernas olikvärdighet, som annars vid »skrivbordsbehandlingen» av observationsmaterialet i alltför hög grad måste komma att vila på den enskilde författarens auktoritet. Vår rika strandlinjelitteratur vittnar ju på denna punkt mycket utförligt om huru meningarna gått isär, varför ett försök att normalisera iakttagelsematerialet synts mig innebära en metodisk vinst.

Halden menar, att min intensitetsmarkering även skulle omfattat de zoner där strandlinjer icke framträda, men sannolikheten likväl låter förmoda att strandens kraftspel varit livligt, yttrande sig i framprepararandet av kalberg och starkt abraderade moränpartier. Det är mycket begärt, att jag skulle i detalj kunnat avgöra vilka hällpartier, som frilagts genom abrasionen, vilken lagermäktighet denna omfattat och vilka moränytor, som i synnerhet blivit denuderade. I min skrift har jag lämnat en hel del anvisningar om dessa förhållanden och har givetvis ännu en hel del opublicerat iakttagelsematerial till dem. Min framställning har ju dock i främsta rummet avsett strandlinjerna och inom de terrängytor, där dylika icke förekomma äro de naturligen redovisade med noll, icke som Halden säger oredovisade. Att inom de strandlinjesaknande ytorna strandens kraftspel även kan han varit betydande har jag bl. a. utförligt belyst med av topografien beroende klapperfält. Men att indraga en intensitetsmarkering för dessa, som jag uppvisat alldeles förvirra bilden av de synkrona strandmärkenas frekvensförhållanden, eller att införa alldeles subjektiva uppskattningar över abrasionens mått vid kalbergsområdena och de denuderade moränytorna, vore att förstöra grunden för undersökningens förnuftiga uppläggning. Hade så gjorts torde en berättigad kritik ha framkommit mot en undersökning, vars mål varit att vinna klarhet om strandmärkenas fördelning. Mina slutsatser beröra dock den allmänna abrasionens storlek och ur totalfrekvenskurvorna för strandmärkesintensiteterna (sid. 34—35) kan utläsas mycket av intresse i dessa frågor, bl. a. huru abrasionen vid Ancylussjöns avstängning femdubblas i styrka för att sedan åter hastigt sjunka. — En studie över abrasionens absoluta mått tillhör en annan undersökning än den jag framlagt.

Vad som här sagts berör i viss mån också Haldens kritik mot sedimentundersökningarna i samband med mina strandlinjestudier. Vid sidan av mina mera kortfattade uppgifter föreligger i Sandegrens beskrivning till kartbladet Storvik en ganska utförlig redogörelse icke blott för de allmänna förhållandena utan många detaljuppgifter låta sig även utläsas. På åtskilliga ställen av min skrift har jag behandlat de distala grusbildningarnas natur och uppkomstförhållanden (sid. 13—14, 16, 20—21, 58—59; kartbladet Storvik s. 103—105). Förhållandena äro dock i allmänhet ej gynnsamma för dylika studier inom området på grund av de distala sedimentens relativt stora mäktighet, som förutsätter omfattande borrningar för att rörande dessa bildningar nå säkrare resultat.

Beträffande den generella uppfattningen om de distala sandackumulationernas natur torde emellertid Haldens och mina uppfattningar gå väsentligt isär. HALDEN har utan tvivel mycket förtjänstfullt bidragit till utredningarna om det distala strandgrusets natur och utbredningsförhållanden, men att från dessa undersökningar beträffande det norrländska kustområdet våga draga slutsatser om att enbart negativ strandförskjutning ägt rum från marina gränsens utbildningstid fram till nutid synes mig oberättigat. Ännu i Gästrikland uppvisar ju havsytan vid Litorinagränsläget icke endast en utan flera positiva strandförskjutningar, som jag har grundad anledning förmoda att ha sträckt sig väsentligt nordligare och jämväl i södra Hälsingland äro fullt tydligt registrerade med distala grusackumulationer. En utförligare kännedom om det senare decenniets stenåldersforskning belyser också så avgörande, huru en betydande procent av de mera detaljerat utgrävda strandboplatserna uppvisa serier av positiva strandförskjutningar just inom distala strandgrusbildningar. Utan tvivel är därför uppfattningen av de distala grusackumulationerna som nära nog eller enbart härstammande från negativ nivåförändring ingalunda i sådan kontakt med det nyare observationsmaterialet, att den må hävda sig som modern gentemot de åskådningar, som räknat med positiva nivåförändringars stora betydelse för de distala grusskiktens uppkomst.

Från mitt undersökningsområde har jag givit ett exempel, där det synes mig sannolikt att en »dubbelbottnad» sedimentserie utgör ett belägg för transgressioner i Ancylussjön efter det sydbaltiska maximets utbildningstid (fig. 31, sid. 58). Den nedre profilen uppvisar här närmast under ett tunt torvdylager ett något mer än halvmetertjockt lager av lerig mjäla, ett typiskt »viksediment», bildat när topografien slutit sig kring den dalgång, som här skildrats (lutningsförhållandena utesluta att det här skulle röra sig om ett vanligt insjösediment). Därunder följer ett halvmetermäktigt distalt gruslager, uppåt dalsidorna grövre. Det vilar på en fet Ancyluslera, som i dalbottnen bildar ett några dm tjockt lager, vilket emellertid uppåt dalsidorna är starkt eroderat och uppdelat i klumpar, inblandade i grövre grus, markerande en bränningszon. Under detta lerlager följer i sin tur ett minst metertjockt lager av grovt distalt strandgrus, som vilar på den vanliga varviga leran, vars kontakt är mycket ojämn och försedd med tydligt eroderade små skikthuvuden. Den intresserade läsaren finner av denna skildring, att det insmugit sig ett lager för mycket i profilen för att den skulle kunna representera en normal regressionsprofil. Just detta fall har teoretiskt diskuterats av HALDEN i hans lärorika gradualavhandling (S. G. U. Ser. C. N:o 280, 1917, s. 12), där följande pretention på en positiv strandförskjutning på ett klart och redigt sätt definieras: »Finkorniga sediment, som ej längre stå under Balticums vattenyta böra enligt min mening för att kunna antyda nivåoscillationer uppvisa tvenne något så när likartade skikt av grövre kornstorlek». Min profil uppfyller eklatant denna fordran, som ju emellertid icke nödvändigtvis behöver vara uppfylld för att nivåoscillationer skola låta sig konstateras (jfr redogörelserna för gyttjelagerföljden under torvmarken vid Österbo, SANDEGREN: kartbladet Storvik sid. 132 ff. och ASKLUND: Gästrikländska fornstrandlinjer sid. 71 ff.)

Fornkustbildningarna i Gästrikland.

Några kompletterande synpunkter

av

BERTIL E. HALDEN.

Med anledning av Dr ASKLUNDS förestående diskussionsinlägg (G. F. F. Bd 58, h. 2) vill jag gärna ånyo understryka, att min inställning till intensitetsgraderingsförsöken, i den mån dessa avse att genom statistisk behandling på sätt som av ASKLUND prövats ge klarhet i fråga om fornvindar och transgressioner, är ganska negativ. Dessa försök måste nämligen enligt min mening tyvärr lämna alltför stort spelrum åt de oåtkomliga momenten, resulterande i en svåruppskattbar osäkerhet hos resultaten.

Ehuru det är vanskligt att av enbart den tryckta framställningen och tillgängliga kartor i detalj klart uppfatta de terrängförhållanden, som ligga till grund för den genomförda statistiken, synas dock åtskilliga framträdande drag ägnade att inge en smula tvivel på denna statistiks tillförlitlighet.

ASKLUNDS ovanstående uppgift om att västsidorna inom skärgården vid tiden för högsta kustlinjens utbildning skulle vara endast obetydligt bättre vågskyddade än övriga expositioner, är alldeles obegriplig. Höjdkartan ger rakt motsatt besked i denna fråga.

En härmed sammanhängande omständighet är, att terrängens exposition mot nordost är utomordentligt tydlig inom stora delar av området. Särskilt gäller detta Söderåsen, varifrån en betydande del av materialet till statistiken är hämtad. Lika klart besked ger höjdkartan om att bergstrakterna W om Storvik äro särskilt exponerade för SO-vindar. Några observationer av strandmärken i sådan exposition finnas emellertid ej angivna å ASKLUNDS karta, som för nämnda område endast upptager sydlig resp. nordlig exposition.

Till undvikande av varje missförstånd rörande storleksordningen av den maximala vägsträcka, för vilken »Stevensons formel» är användbar, må här enligt nyare bearbetningar och med hänsyn tagen jämväl till förhållandena i Östersjön anföras siffran 370 kilometer. (För en mer kvalitativ uppskattning kunde eljes hänvisas till de olika erfarenheterna av vågbildningen som envar kan göra under båtfärder å ena sidan inomskärs, å andra sidan utomskärs vid lika stark havsvind.)

Mitt uttalande om att bästa vågskyddet i Gästrikland enligt ASKLUNDS framställning — även om jag ej godtager beräkningsmetoden — tillkommer västliga och sydliga expositioner grundade sig på figg. 11, 21 och 22 i hans avhandling men avsåg ej särskilt de högsta nivåerna, då de ju jämfördes med de postglaciala i Hälsingland.

Nivån c:a 175 m ö. h. spelar en viss roll för ASKLUNDS resonemang och säges bl. a. (sid. 25) representera ett maximum även i nordlig exposition å Söderåsen. Man frågar sig, hur detta är möjligt, då observationerna för de nordliga expositionerna (linjerna 12 och 13) upphöra vid nämnda nivå. Att de högre än 175 m belägna strandmärkena uppvisa reducerad intensitet även i sydlig exposition kan beträffande linje 8 mycket väl tänkas bero på att — om man får döma efter kartan — denna linjes högsta del i själva verket är exponerad mot SW.

Ovanstående exempel utöver de i min Siljans-avhandling andragna äro här meddelade, alldenstund de synas mig berättiga till den slutsatsen, att den förebragta statistiken icke motsäger möjligheten av helt andra orsaker än vindstyrka och transgression såsom avgörande för vissa väsentliga drag i traktens strandbildningar. Min egen åsikt i frågan — vågeffektens beroende i främsta rummet av strandens riktning och de mer eller mindre effektiva, av skärgårdsbildningen betingade svallskydden — har erhållit ett synnerligen kraftigt stöd genom de analoga undersökningar, som i Finland utförts av SEGERSTRÅLE (Fennia 47, 1927). Särskilt upplysande i detta hänseende är fig. 11 i den åsyftade avhandlingen samt uttalandena å sidd. 27—29, avslutade med den sammanfattande meningen »att en tydlig motsvarighet till de för de svenska skalmärgelfyndigheterna utmärkande expositionsförhållandena kan iakttagas i fråga om förekomsterna i vårt land».

Med avseende på de mellanlagrande grusskiktens etc. uppkomst har ASKLUND ansett sig finna ett medgivande för transgressionshypotesen i ett mitt uttalande (S. G. U. Ser. C., 280, sid. 12). Där talas om att vissa lagerföljder med dubbla grusskikt kunna »antyda» nivåoscillationer. Den därpå följande, av ASKLUND uteslutna meningen (»att genom successiv isolering av olika höjdpartier distala strandgrusskikt av flere ordningar kunna uppstå» etc.) avser att markera den stora differensen mellan en antagen möjlighet och ett bevis. I den åsyftade avhandlingen (Tavl. I, Finntjärn och Smälskmyra) ses sådana exempel på upprepning av grovsedimentens uppträdande som saknar känd motsvarighet i de hittills undersökta lagunstadierna, vilkas antal f. ö. genom senare undersökningar är vida större än de 1917 föreliggande.

I några närmare undersökta specialfall har jag kunnat påvisa pollenanalytisk eller därmed analog överensstämmelse mellan å ena sidan vartdera av två i samma lagerföljd på olika djup uppträdande grus- eller sandskikt och å andra sidan just de lagunstadier, som till sitt höjdläge svara mot topparna av tvenne olika högt och på olika avstånd belägna jord- eller bergshöjder, som framträda i terrängen kring resp. lagerserie; icke i något fall har en sådan undersökning givit negativt resultat.

Att andraga arkeologiska fyndomständigheter i samband med distala strandgrusskikt såsom bevis för transgressioner synes mig med förlov sagt vara ett mycket farligt tillvägagångssätt, föga säkrare än när man av statistik på grund- och djupvattensformer bland enheterna i en skalgrusavlagring söker bevis för nivåoscillationer.

Som bevis för havstransgressioner i Gästrikland anföras vidare vissa detaljer i Österbotorvmarken. Jag har tagit del av diatomacéanalysen från den omstridda, av betydande sötvattenstillflöden påverkade lagerserien och därvid funnit den mest sannolika tolkningen vara den av SANDEGREN uttalade. Vissa detaljer i den tills vidare endast preliminärt utförda analysen kunna rent av anses tyda på att saltvattensinslagen i lagerseriens övre delar snarare överskattats än negligerats (jfr G. LUNDQVISTS och H. THOMASSONS ekologiska och topografiska passpunktsnivåer, G. F. F. 1923 sid. 383). Den inlagrade brunmosstorven har enligt muntligt meddelande av

Dr Sandegren karaktären av en gungflybildning, som genom nedsjunkning kommit att intaga sin plats på gyttjan.

För dem som alltjämt känna sig tilltalade av hypotesen om transgressioner, registrerade av leror vilande på sand- eller grusskikt i den mellan- och nordsvenska kvartären, rekommenderas ett studium resp. en revision av de innehållsrika profiler, som finnas återgivna i beskrivningen till geol. bladet Uppsala, fig. 1, samt i Paijkulls halvt avglömda gradualavhandling: »Om de lösa jordlagren i en del af Mälaredalen» (Stockholm 1860), fig. 4, 5 och 7. Ett systematiskt studium av dessa och liknande lagerserier skall otvivelaktigt ge som resultat, att hela den tid, som förflutit sedan högsta kustlinjen utskulpterades, är så att säga späckad av detta slags transgressioner. Den ingalunda föraktliga erfarenhet, som fornsjöforskarna av facket redan insamlat under de senare decennierna, utgör emellertid en ganska god borgen för att dessa »transgressioner» i flertalet fall skola visa sig behäftade med den lilla egenheten att icke kunna återfinnas i de till tiden motsvarande, för varje förändring i nivåhänseende så känsliga lagunstadierna. Positivt givande blir helt visst ett dylikt studium i och med att samtidigt den omgivande terrängens detaljer registreras, varvid särskilt de forntida svallfronternas och svallskyddslägenas höjdvärden angivas. Att dessutom tillfälliga stormar någon gång kunna hava föranlett utsvämning av grus- och sandskikt från stränderna oberoende av terrängens detaljer (G. De Geers »stormskikt»), måste alltjämt anses sannolikt.

Mötet den 5 mars 1936.

Närvarande 35 personer.

Ordföranden, Hr N. Magnusson, öppnade mötet, varefter revisionsberättelse över styrelsens och skattmästarens förvaltning under år 1935 föredrogs, och av revisorerna tillstyrkt ansvarsfrihet beviljades.

Sammandrag av Geologiska föreningens räkenskaper för år 1935.

Debet.

Balans från 1934:	Reservfondens konto	kr.	9 831: 20	
	Lotterifondens »	»	34 210: 83	44 042: 03

Inkomster under 1935:

Reservfondens konto, räntemedel	kr.	408: 21	
» » , ständiga ledamöters avgifter	»	400: —	
Lotterifondens » , ränta	»	1 650: —	
Annonsbilagans »	»	224: 61	
Trycknings- och korrigeringsbidrags konto	»	1 459: 50	
Försäljning av föreningens förhandlingar	»	849: 32	
Statsbidrag	»	1 700: —	
Bidrag av Jernkontoret	»	1 000: —	
Årliga ledamotsavgifter	»	4 740: —	
Portoersättningar	»	163: 28	12 594: 92

Utgående balans:

Skuld till P. A. Norstedt för tryckning	kr.	725: 24	725: 24
		Summa kronor	57 362: 19

Kredit.

Utgifter under år 1935:

Geol. fören. förh., årg. 1934, rest å tryckning	kr.	1 237: 07	
» » » » 1935, tryckning	»	9 875: 38	
» » » » » , » ogulden	»	725: 24	
» » » » » , illustrationer	»	650: 42	
» » » » » , distribution	»	514: 58	
Expeditionskostnader	»	527: 96	
Mötena	»	276: 88	
Arvoden	»	1 350: —	
Referat	»	84: 30	
Brandförsäkring och diverse	»	50: 50	
Revue annuelle	»	258: 50	15 550: 83

Utgående balans:

Reservfondens konto	kr.	10 231: 20	
Lotterifondens »	»	31 580: 16	41 811: 36
		Summa kronor	57 362: 19

Föreningen beslöt ingå till Kungl. Maj:t med ansökan om ett anslag av kr. 1 700 och till hrr fullmäktige i Jernkontoret med ansökan om ett anslag av kr. 1 000 såsom bidrag till fortsatt utgivande under år 1936 av Föreningens Förhandlingar.

Hr P. THORSLUND höll ett av ljusbilder illustrerat föredrag om: Några stratigrafiska och tektoniska rön från Siljansområdet.

Föredr. berörde först kortfattat de undersökningar, som ha samband med fastställandet av Orsasandstenens stratigrafiska läge, och påvisade med stöd av förefintliga litteraturuppgifter, att sandstenen sannolikt vilar med erosionsdiskordans på den fossilförande siluren. Där kontaktförhållandena något så när kunnat fastställas, har nämligen sandstenens liggande visat sig bestå antingen, såsom vid t. ex. Styggforsen, av den s. k. cementkalken, d. v. s. retiolitesskifferledets översta del, eller också av bumastuskalk. Den sistnämnda, som endast anförts från Nederberga i Orsa s:n, namngavs av TÖRNQUIST, vilken ansåg densamma utgöra de yngsta fossilförande lagren inom områdets silur och vara såväl i petrografiskt som faunistiskt avseende tydligt skild från den äldre cementkalken. Vår kännedom om Dalarnas översta fossilförande silurbildningar måste emellertid ännu betraktas såsom mycket ofullständig, varför en noggrannare undersökning av dem bör kunna ge närmare besked om den förmodade diskordansens storlek samt givetvis även (tack vare sedan sekelskiftet tillkomna stratigrafiska utredningen över siluren inom andra områden och därigenom förefintliga möjligheter till korrelation) kunna bidraga till att i någon mån fixera Orsasandstenens ålder. Denna torde ännu få anses vara en öppen fråga, oaktat HADDINGS omnämnande av fossilfynd i sandstenen. Föredr. framhöll nämligen som sin åsikt, att meddelandet av dessa mycket betydelsefulla fynd har en så preliminär karaktär, att man svävar i ovisshet, om man verkligen kan räkna med dem för en datering av Orsasandstenen. I den petrografiska beskrivningen av den fossilförande sandstenen har HADDING kraftigt understrukit, att de fossila skalen äro mycket nötta, vilket otvunget leder tanken till den i detta fall ingalunda uteslutna omständigheten, att fossilen törhända förekomma i sekundärt läge i sandstenen.

Det andra stratigrafiska avsnittet av föredraget utgjorde huvudsakligen en demonstration i bild av äldre och nyare uppfattning av den s. k. leptaenakalkens uppträdande i lagerserien. En utförligare framställning i denna sak samt av några senare skildrade tektoniska iakttagelser vid vissa revkalkförekomster kommer att inflyta i S. G. U:s publikationsserie.

Såsom huvudtema behandlades områdets ceratopygeled ur synpunkten på dess användbarhet för utredandet av det subordoviciska landskapets morfologi. En detaljgranskning av de hittills kända profilerna genom ceratopygelagren visade, att dessa ha en likartad utbildning och jämförelsevis obetydliga mäktighetsvariationer inom de delar (i S och O) av Siljanstrakten, där underlaget består av äldre urberg (gnejs och granit). Norrut utgöres liggandet övervägande av blandad porfyr- och sandstensberggrund, och här framvisa de ordoviciska bottenlagren större omväxling i berörda avseenden. Detta demonstreras av trenne profiler, av vilka tvenne tidigare äro kända genom beskrivningar av Törnquist, Holm och Wiman. Den senare kunde genom företagen grävning vid Kårgärde i sluttningen mot Orsasjön påvisa, att mellan härstädes anstående porfyr och planilimbatakalk ligger ett 0,24—0.42 m mäktigt lager glaukonitlera med porfyrfragment, i smärre fördjupningar av underlaget även större bollar av porfyr och fosforit. I den av Törnquist och Holm beskrivna profilen vid Talubäcken i Skattungbyn befanns den huvudsakligen av graptolitförande skiffer (undre didymograptusskiffer) ersatta planilimbatakalkzonen och porfyren vara skilda åt av ett ungefär fotstjockt lager av grönaktig kalk med porfyrbollar jämte påliggande glaukonitrikt kalkskikt. Sannolikt tillhöra såväl glaukonitleran vid Kårgärde som »grönkalken» i Skattungbyn cerapygeledet, ehuru bristen på fossilfynd i bägge fallen göra bestämningen oviss.

Den tredje profilen tillkom för ett par år sedan i samband med vägarbeten vid Djupgrav och västerut från denna ravin och är belägen c:a 2 km V om Talubäcken. Berggrunden i vägskärningarna från Skattungbyn till ett par hundra m bortom Djupgrav utgöres av Digerbergssandsten. Endast närmast byn framsticker röd porfyr. Sandstensserien avslutas överst eller närmast under de ordoviciska lagren av finkornig grå och tegelröd sandsten med inlagrade tunna lerskifferskikt.[1] Härpå följa så med samma branta stupning som sandstensserien eller 85° åt N 15°V (fig. 1):

1.	Konglomerat	3,20 m
2.	Lerig glaukonitsand, underst med bollar av porfyr m. m. .	0,32 »
3.	Glaukonitförande grön- och rödaktig kalksten	0,33 »
4.	Tunnskiktad grå, i en mittzon röd kalksten växellagrad med skiffer	1,55 »

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[1] Det var tydligen denna del av sandstensserien, Törnquist avsåg och sammanblandade med Orsasandstenen, då han vid Skattungbyn sökte stöd för sin uppfattning, att den sistnämnda utgjorde liggandet till de fossilförande lagren. (Senare tillägg under diskussionen.)

Blottningar saknas sedan på en kortare sträcka, där säkerligen en förkastning går fram, ty västerut återkommer först några m sandsten och därpå en lagersvit, vars undre del är så gott som identisk med den beskrivna profilen. I denna hade endast lager 4 medelst fossilfynd kunnat bestämmas; det tillhör planilimbatazonen. Konglomeratet har underst mera sandstensmassa än bollar men uppåt blir bollmaterialet övervägande. Bollarna äro väl rundade och bestå mestadels av porfyr men sådana av bl. a. Digerbergssandsten och röd kvartsitsandsten ha iakttagits. Porfyrbollarna kunna nå en största genomskärning av 1,5—2 dm. Fosforitbollar ha icke iakttagits, men överst är 2 dm av konglomeratet mörkfärgat, sannolikt av fosforitbelägg på sandstenskornen i mellanmassan (fosforhalt påvisad vid kemisk undersökning men ej bitumenhalt). Konglomeratet liknar icke i Digerbergssandstenen förekommande konglomeratlager, och tillhör säkerligen den ordoviciska lagerserien, i vilken det intager samma plats som oboluskonglomeratet. Detta senare har av HADDING ansetts representera ett intraformationalt regressionskonglomerat, en uppfattning, som ur allmän-geologisk synpunkt knappast kan vara berättigad, då ju kambrium saknas eller i varje fall icke kunnat påvisas inom området och då vi ju för övrigt äga så många bevis för att ordovicium inleddes med en transgression över det skandinaviskt-baltiska området. HADDINGS sedimentpetrografiska undersökning har emellertid ådagalagt, att större delen av oboluskonglomeratet utgör en bildning tillkommen genom omlagringar under — såsom HADDING även framhållit — oscillatoriska nivåförändringar. Rester av det primära transgressionskonglomeratet böra likväl finnas här och var och såsom en sådan rest torde större delen av konglomeratet i Djupgravsprofilen kunna uppfattas.

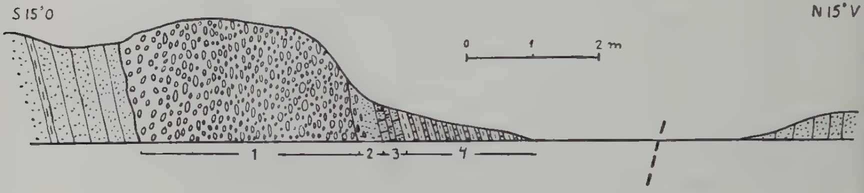

Fig. 1. Djupgravprofilen, förklaring se texten.

Resultatet av en granskning av Siljansområdets ceratopygelager eller — rättare uttryckt — de lager, som ha planilimbatazonen till hängande, blir bl. a. följande. Mäktighetsvariationen hos dessa lager är relativt ringa och faller mellan ungefär 2—3 dm och 3.5 m. Denna visserligen tämligen obetydliga variation äger rum huvudsakligen inom det gebit, där underlaget utgöres av blandad profyr- och sandstensberggrund. Där spåras även mera betydande faciesväxlingar än inom ost-sydliga delar av området.

Den jämförelsevis ringa mäktighetsvariationen hos ifrågavarande del av lagerserien utsäger, att det ordoviciska havet inunderade ett föga kuperat landskap, om än en antydan om en något mera skärpt topografi norrut likväl förefinnes. Den oscillatoriska transgressionen skulle givetvis ha framkallat en sedimentanhopning till sänkorna och därigenom större skillnader i mäktighetssiffrorna, i fall det subordoviciska landskapet icke representerats av en tämligen plan landyta. Föredr. ville emellertid göra sannolikt, att den subordoviciska landytan inom Siljansområdet i stort sett sammanfaller med en yta av betydligt högre ålder, nämligen den prekambriska, vilken ju såsom A. G. Högbom och senare särskilt Asklund framhållit till väsentlig del utformats till ett peneplan i subjotnisk tid. Inom större delen av området eller närmare bestämt det ost-sydliga avsnitt, där ordoviciums underlag utgöres av äldre urberg, skulle sålunda den subjotniska landytan funnits bevarad eller snarare utpreparerad vid den ordoviciska transgressionen.

Möjligheten till denna datering synes vara ganska stor. Vi ha ju här längst i norr det sydliga gränspartiet av området för de — åtminstone hittills — såsom subjotniska betecknade dalaporfyrerna och inom detta gebit en sandstensserie, den s. k. Digerbergssandstenen, vars översta del i preordovicisk tid sannolikt haft betydligt större utbredning och säkerligen en gång täckt hela det område, vi nu benämna Siljansområdet. Påvisandet av sprickfyllnader av denna sandsten i de fossilförande lagrens liggande inom de delar, där detta utgöres av äldre urberg, skulle givetvis besanna denna förmodan. Ett fynd av dylik art kan dock endast bero på en lycklig tillfällighet, då ju den subordoviciska ytan på grund av senare förkastningsrörelser oftast har mycket brant stupning och därför knappast blir blottad annat än i smärre skärningar. Från oboluskonglomeratet vid Sjurberg (inom granitområdet) har dock Hedström omnämnt bollar av röd skiffer, som uppenbarligen kommit från äldre sedimentära lager.

Digerbergssandstenens åldersfråga har givetvis betydelse i detta sammanhang men om dess jotniska ålder torde näppeligen något tvivel kunna råda, då den ju utgör de omlagrade sönderdelningsprodukterna av dalaporfyrerna och andra bergarter i anslutning till dessa. Föredr. åsyftade härvid närmast den del av sandstensserien, som kommer intill de ordoviciska lagren inom undersökningsområdet — såsom vid Vångsgärde i sluttningen mot Orsasjön, Granån och vid Djupgravsprofilen — men icke de tuffbildningar, som Looström avsett med benämningen Digerbergssandsten. Däremot torde den tåla en jämförelse med de av VON ECKERMANN i dennes preliminära redogörelse för Loos-fältets geologi såsom Dalasandstenar och konglomerat betecknade bildningarna.

Sandstenen är förkastad tillsammans med de fossilförande lagren och uppvisar runt den inre bården av »silurringen» samma stupningar som dessa. I subordovicisk tid torde den därför och såsom framgått av undersökningarna av ceratopygeledet huvudsakligen ha utgjort dalfyllnader i en åt N och NV sannolikt alltmera kuperad porfyrterräng.

Litteratur.

B. ASKLUND (1924). Mälarporfyrernas läge och sandstensområdet på Ekerö. G. F. F. Bd 46.

— (1931), i Ramsay: Geologiens Grunder, 3:dje uppl.

H. v. ECKERMANN (1934). A Preliminary Report on the Geology of the Loos Region. G. F. F. Bd 56.

A. HADDING (1927, 1929). The Pre-Quarternary sedimentary rocks of Sweden, I -II, III. Lunds Univ. Årsskr., Ny Följd. Bd 23 o. 25.

H. HEDSTRÖM (1896). Till frågan om fosforitlagrens uppträdande och förekomst i de geologiska formationerna. G. F. F. Bd 18.

— (1919). Kort rapport över fosforitundersökningarna i Dalarna sommaren 1918. S. G. U:s Arkiv.

G. HOLM (1882). Über einige Trilobiten aus dem Phyllograptusschiefer Dalekarliens. Bihang till K. V. A. Handl. Bd 6, N:o 9.

A. G. HÖGBOM (1910). Precambrian Geology of Sweden. Bull. Geol. Inst. Upsala, Vol. X.

R. LOOSTRÖM (1916). Die Unterlage der Elfdalgesteine im Kirschspiel Orsa. Bull. Geol. Inst. Upsala, Vol. XV.

G. C. v. SCHMALENSÉE (1892). Om lagerföljden inom Dalarnas silurområden. G. F. F. Bd 14.

M. STOLPE (1872, 1884). Om Siljanstraktens sandstenar, 1 och 2. G. F. F. Bd 1 o. 7.

S. L. TÖRNQUIST (1877). Nyblottad geologisk profil med Phyllograptusskiffer i Dalarne. G. F. F. Bd 3.

— (1883). Öfversikt öfver bergbyggnaden inom Siljansområdet i Dalarne. S. G. U. Ser. C, N:o 57.

— (1886). Några iakttagelser från sommaren 1885 öfver omtvistade delar af lagerföljden inom Dalarnes silurområden. G. F. F. Bd 8.

C. WIMAN (1906). Om Ceratopygeregionen inom Siljanssiluren. G. F. F. Bd 28.

Med anledning av föredraget yttrade sig hrr LOOSTRÖM, BACKLUND, ASKLUND, TROEDSSON, HALDEN (se notis sid. 359 i detta häfte av Förhandlingarna), HOLMQUIST och föredraganden.

Hr LOOSTRÖM framhöll, huru värdefulla dessa föredragandens noggranna detaljarbeten i fält äro för uppredandet av den komplicerade tektoniken inom norra Dalarna. I sitt meddelande om Älvdalsformationen[1] hade tal. omnämnt, att de på TÖRNQUISTS karta utsatta hällarna av Älvdalsserien bestå av dels Digerbergssandsten och dels porfyrit av den typ, som utgöra bottenlagren i Älvdalsformationen. Norra Dalarnas prekambriska sandstenar och silur överlagra Älvdalsformationen, och bevis för detta är ej blott, att sandstenens bottenkonglomerat hålla bollar av Älvdalsbergarterna utan kan ock här tilläggas, att tal. funnit en sandstensgång av prekambrisk typ i Månstaberget, Älvdalens s:n. Genom de talrika förkastningarna inom silurområdet ha partier av Älvdalsserien horstliknande förskjutits uppåt och sedermera blivit blottade genom denudation.

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[1] Die Unterlage der Elfdalgesteine. Bull. of Geol. Instit. of Upsala. Vol. 15.

Älvdalsformationens gräns mot söder till siluren utgöres såsom man vet av förkastningar, men även mot bergarterna öster ut på andra (västra) sidan Siljan i Mora socken är Älvdalsformationen begränsad av förkastningar. En serie av sådana gå fram från öster till väster och avskära tvärt Älvdalsseriens utbredning åt söder. Här har ej berggrunden blivit sänkt såsom inom silurområdet, utan rörelsen har huvudsakligen haft motsatt riktning, så att Älvdalsserien underlagrande bergarter träda fram. Förkastningarna ha varit så stora, att till och med mycket djupt liggande lager ha blottats, såsom kvartsit i Karlsberget och kvartsporfyr i S. Garberget, Näsklitt och Leksberget, vilka båda bergarter erinra om Loosfältets bergarter. Att dock även sänkningspartier förefinnas här bevisa förekomster av Digerbergssandsten vid Ryssa och Dalasandsten vid Larstjärn.

Föredr. hade uppvisat områden av Digerbergssandsten inom siluren, och ville tal. påminna om, huru tråkigt det är, att denna bergart, som blott sporadiskt uppträder i Digerberget och utan att man där kan visa dess geologiska ställning, likväl fått och får behålla sitt namn. Digerbergssandstenen är, som tal. visat, en pyroklastisk bildning, vilken uppträder mellan eruptionsströmmarna i Älvdalsserien. Den intager inom detta fält vidsträckta arealer. Det största området sträcker sig från Nässjön i Älvdalens s:n väster ut över Våmhus s:n och långt in i Orsa socken och ett annat område förefinnes vid Ämån i trakten av Ämådalens station. Digerbergssandstenen framträder särskilt storartat norr om Nässjön i Älvdalen, där en profil genom densamma är blottad i de höga bergväggarna. I östra änden av Nässjön kommer botten för denna bergart, som har flack stupning åt VNV, till synes och utgöres av porfyrit. Digerbergssandstenen kan från denna plats följas uppåt i lagerserien genom blottningar i bäckar, tvära branter och väldiga bergsstup. Den är uppbyggd av pyroklastiskt material, dels finkornigt och då på sina ställen skiktad och dels av agglomerat i gigantiska proportioner. Dessutom uppträda växellagrande inom densamma smärre porfyritbäddar. Digerbergssandstenen kan följas i ett sammanhang från Nässjöns östände upp genom Hykieberget och därefter väster ut i Uvbergen fram norr om sjön till berget Vitturn vid Klittens by. Här överlagras den av porfyrit, och kontakten är tydligt blottad.

Att Digerbergssandstenen är en helt annan formation än Dalasandstenen ville tal. särskilt framhålla. Dalasandstenen visar tydligt i vidsträckta områden med utpräglade böljeslagsmärken, att den är en grundvattensbildning.

Hr B. Asklund framhöll det stora värdet av föredrag:ns nya iakttagelser, som ju fört kunskapen om det genom de kvartära avlagringarnas utbredning så svårstuderade området mycket väsentligt framåt.

Med anledning av Dr Looströms yttrande syntes det fullt tydligt, att bergarter med den s. k. Digerbergssandstenens typ och stratigrafiska ställning som ett subjotniskt, pyroklastiskt sediment verkligen förekomma innanför kambrosilurringen. Av de prekambriska sandstensbildningar, som förekomma inuti ringen, hade tal. endast sett de, som komma de fossilförande lagren närmast i trakten av Orsa. Dessa kunde enligt tal:s mening knappast tänkas intaga annan stratigrafisk ställning än Dalasandstenen. De äro såsom framhållits av H. VON ECKERMANN icke pyroklastiska utan förete fullständig överensstämmelse med normal Dalasandsten, med dennas rikedom på porfyrbollar inom de mera konglomeratiska partierna.

Dr LOOSTRÖM hade framfört frågan om diabasen vid Åberga i Orsa möjligen skulle kunna vara postsilurisk, i enlighet med TÖRNQUISTS uppfattning. Vid ett besök på platsen under sistlidna sommar hade tal. låtit utföra en grävning, som blottat kontakten mellan diabas och ortocerkalksten. Ehuru kontaktplanet såsom ofta i Siljansområdet torde vara tektoniskt och sålunda sekundärt, åstadkommet vid en mindre rörelse mellan de olika bergarterna, uppvisar dock diabasen här en kontaktförtätning, som knappast kan tolkas annat än som bevis för diabasens postordoviciska ålder.

Tal. hade emellertid funnit ett annat bevis för att postkambrosiluriska diabasgångar förekomma inom trakten. Vid Stumnsnäs i Rättvik förekommer nära intill bryggan ett märkligt litet hällområde av en grov granitbreccia. Denna kommer i direkt kontakt med och kringgränsas till stor del av röd ortocerkalk, som i brist på karakteristiska fossil ej kunde nivåbestämmas, men som tal. förmodade tillhöra »övre röd». Där breccian kommer i kontakt med kalkstenen är även den senare breccierad. I stranden förekomma i granitbreccian ett par mindre, basaltliknande gångar, delvis övergående i väl avgränsade, mörka agglomerat- eller brecciegångar.

Den mikroskopiska undersökningen hade fastställt, att det här föreligger en tät, nu starkt saussuritiserad diabas, sålunda av postordovicisk ålder. Den rundade breccian, vars genomskärning uppgick till 15 à 20 m tolkade tal. som en vulkanisk explosionsbreccia och erinrade därvid om HERMAN HEDSTRÖMS fynd av agglomeratartade sprickgångar vid Sjurberg och andra lokaler inom Siljansområdet samt att HEDSTRÖM alldeles riktigt tolkat dessa bildningar som vulkaniska.

Om det härmed är konstaterat att Siljansområdet verkligen håller »postsiluriska» eruptivbergarter, uppställer sig frågan om vilken ålder dessa kunna förmodas äga. Den grövre Åbergadiabasen röjer en viss frändskap med essexitiska diabasarter och man kunde därför möjligen tänka på att sammanhålla den med permiska eruptiv. Att den permiska diastrofismen även kunnat göra sig gällande här fann tal. möjligt bl. a. därigenom, att avståndet till områden, där denna gjort sig gällande, ej var alltför betydande (Mjösenområdet, NV-ligaste Dalarne).

Tal. hade sökt bilda sig en mening om kambrosilurringens uppkomsthistoria. I RAMSAYS Geologiens Grunder, 3:dje uppl., hade tal. betecknat siluromrädet som ringformigt införkastat och menade därmed att det vore danat genom vulkanisk instörtning. Vid fältgranskningen hade tal. funnit, att hela den s. k. »kupolen» egentligen utgör en insänkt cirkelformad yta, vars centrala partier blott i förhållande till de starkt denuderade fossilförande bildningarna framstår som en kupol, men i förhållande till omgivande prekambrisk berggrund är avsänkt, uppskattningsvis 100 à 200 m. Detta faktum i förening med existensen av förkastningsringen tyder klart på att

Siljansområdet anlagts vid vulkanisk verksamhet, i samband med aktivitet från en centraleruption, vars kärnområde befinner sig under »kupolen». Genom ringformig anläggning av tensionssprickor längs konformiga, inåtstupande rörelseplan kan man förklara uppkomsten av de märkvärdiga, ofta brantstående upprepningarna av den kambrosiluriska lagerföljden, som iakttagas vid Fjäcka, Sjurberg m. fl. lokaler. Dessa bilda det äldre tektoniska momentet från den tid, då genom den vulkaniska aktiviteten »kupol»-området pressats uppåt. De märkliga av THORSLUND funna överskjutningarna tillhöra ett yngre moment, då aktiviteten upphört efter sannolikt betydande agglomerat- och gaseruptioner. Kupolområdet sjönk då in efter konformade utåtstupande förkastningsplan, varvid de relativt mjuka kambrosiluriska täckbergen hopskrynklades vid ringens yttre periferi och delvis skötos över ringens mindre perifera partier.

Breccior av agglomerattypen ha mycket betydlig utbredning, men deras beskaffenhet och uppkomsthistoria har icke varit förstådd. En stor del av dem har TÖRNQUIST å sin geologiska karta markerat som hälleflinta och s. k. Digerbergssandsten, men bland dessa bildningar ingå agglomerat uppkomna i samband med vulkanismen. De ha betydlig utbredning t. ex. vid Skattungbyn och utmed nya landsvägen mellan Skattungbyn och Åberga. De likna i sin typiska utbildning alldeles de agglomerat, som tal. funnit vid de embryonala vulkanområdena Tvären i Södermanland och Lumparen på Åland.

Områdets vulkaniska tektonik motsvarar överraskande väl den allmänna teori rörande vulkaniska instörtningar och eruptioner som med avseende på centraleruptioner framställts av Dr E. M. ANDERSON (Tertiary and Post-Tertiary Geology of Mull, Loch Aline, and Oban, Mem. Geol. Surv. Scotland, Edinburgh 1924, pp. 11—12).

Vid mötet utdelades N:o 404 av Förhandlingarna.

Mötet den 2 april 1936.

Närvarande 42 personer.

Ordföranden, hr N. H. MAGNUSSON, meddelade, att styrelsen till ledamöter i Föreningen invalt Amanuensen Fil. Mag. KARL ERIK BERGSTEN, Lund, föreslagen av hrr NELSON och HEDE samt Bergsingenjören P. LAGERHJELM, Finspång, föreslagen av hr TROEDSSON.

Utdelades en från den finska kommittén för det Nordiska (19 skandinaviska) Naturforskarmötet i Helsingfors den 11—15 augusti 1936 utsänd cirkulärskrivelse n:o 1. Intresserade kunna erhålla ytterligare exemplar av cirkulärskrivelsen genom sekreteraren.

Hr Geijer höll ett med stuffer illustrerat föredrag över: Några malmfyndigheter i Västtysklands devon.

Föredr. hade med understöd från Jernkontoret företagit en studieresa, huvudsakligen ägnad Siegerland samt Lahn- och Dillområdena. Han betonade Siegerlands ökade betydelse för den tyska järnindustrien och redogjorde kort för nutida uppfattningar och problemställningar ifråga om järnspatsgångarnas uppkomst och beroende av tektoniska förhållanden. Särskild uppmärksamhet ägnades den av områdets gruvföretag organiserade och bekostade distriktsgeologtjänsten i Siegen och dess betydelse för gruvdriften, framförallt vid planläggningen av undersökningsarbeten. Ifråga om där tillämpade arbetsmetoder framhölls den av platsens innehavare, Dr W. Henke, med mycket stor framgång använda metoden att utnyttja stereogram för åskådliggörande av malmgångarnas position, förkastningar, o. s. v.

Besöket i Lahn- och Dillområdena hade haft till ändamål förvärvandet av en viss personlig erfarenhet av där uppträdande bergarter och malmtyper, då den förefintliga rikhaltiga facklitteraturen svårligen kan effektivt utnyttjas utan stöd av dylik förtrogenhet med de lokala geologiska begreppen. De lagerformigt uppträdande blodstensmalmerna hava förr tolkats såsom antingen metasomatiska eller sedimentära. Numera synes det emellertid klart, att metasomatiska processer icke spelat någon större roll. I alla händelser har malmavsättningen skett såsom en slutfas av den vulkaniska verksamheten i mellandevonisk tid. Denna verksamhet började med keratofyreruptioner, varpå följde en mäktig serie av spilitlavor, »slaggkalker» och tuffer; de båda sistnämnda begreppen motsvara beteckningen »Schalstein». Föredr. uppehöll sig vidare vid prof. E. Lehmanns intressanta resultat från petrografiska undersökningar av denna eruptivserie, i vilken framförallt förekomsten av »kalispiliter» utgör ett nytt och högst märkligt drag. Vissa jämförelser med Lake-Superior-områdets grönstenslavor och till dem anknutna kvartsrandmalmer gjordes också.

Föredr. underströk, att studieprogrammets genomförande inom den korta tid, som stått till buds, möjliggjorts genom det stora tillmötesgående, som visats av de inom de ifrågavarande områdena verksamma fackmännen.

Med anledning av föredraget yttrade sig hrr Sundius, Backlund och föredraganden.

Hr N. Sundius instämde med föredr. i hans uttalande om det stora intresse ur flera synpunkter, som de berörda tyska områdena ha för våra svenska förhållanden. För egen del ville tal. beträffande Lahn-Dillområdets bergarter framhålla en omständighet, som i främsta rummet fångat hans uppmärksamhet, och som syntes honom betydelsefull, nämligen den egenartade mineralsammansättningen hos de med malmerna förknippade eruptivbergarterna (keratofyrer, keratofyrspiliter, Schaalstein). I stort sett sammansättas dessa av alkalifältspater, klorit och växlande mängder karbonater, vilka senare i de massiva och homogena bergarterna vanligen icke äro rikliga, vartill kommer ett stundom osedvanligt rikligt innehåll av järnmalm. Denna mineralkomposition är konstant inom serien. Man har i allmänhet tytt detta såsom beroende på sekundär omvandling, orsakad av metamorfos under lagrens veckning. Gent emot detta har likväl Prof. E. LEHMANN i Giessen, som sedan flera år varit verksam inom området, gjort gällande, att denna ståndpunkt icke är tillämplig, utan kombinationen alkalifältspat-klorit måste anses såsom primär och såsom resultatet av direkt utkristallisation ur magman. De skäl, som LEHMANN anför för sin uppfattning, syntes tal. så starka, att man har anledning att godtaga denna såsom riktig. Sålunda saknas inom de nämnda bergarterna alla spår av pseudomorfoser av kalksilikater sådana som hornblände och pyroxen. Däremot är pyroxen en vanlig och väl bibehallen beståndsdel i den något högre i lagerserien belägna »Deck»-diabasen, som genomgatt samma dislokationsperiod, som keratofyrspilitserien. Även i mindre keratofyrintrusioner i diabasen möter man samma motsättning i mineralsammansättningen. Enligt LEHMANN skulle vi därför i den malmförande serien ha att göra med magmatiska bildningar av egenartad sammansättning, för vilka normala stelningsbetingelser icke varit gällande, utan vilkas kristallisationstemperatur legat osedvanligt lågt, varigenom kloritens direkta utkristallisation möjliggjorts. Den huvudsakliga orsaken härtill anser samme forksare vara att söka i en hög vattenhalt. De beskrivna förhållandena i bergarterna svara på det närmaste emot, vad tal. tidigare framhållit såsom utmärkande för senmagmatiska magmafraktioner, och det syntes tal. efter LEHMANNS förtjänstfulla och omsorgsfulla arbete påtagligt, att vi här ha att göra med en senmagmatisk magma i effusiv eller helt ytligt intrusiv form. Att en magma av denna sammansättning bör vara rik på lösningar och ha chanser att alstra malmdepositioner är ju även förståeligt.

Föredraganden var fullständigt ense med Dr SUNDIUS i att tillmäta de av denne framhållna egenskaperna hos Lahnspiliterna den största betydelse ur petrografisk synpunkt. Med hänsyn till svårigheten att gå närmare in på ifrågavarande drag utan att upprulla hela det komplicerade spilitproblemet hade han emellertid i föredraget inskränkt sig till att framhålla sådana drag, som syntes innebära alldeles särskilt nya moment i denna problemställning, nämligen kalispiliterna.

Fil. Lic. TORE LINNELL höll ett av stuffer och ljusbilder illustrerat föredrag om: Nya fynd av tertiär ved i Skåne.

År 1934 påträffades ett antal fossila, förkislade vedstycken i de lösa jordlagren på västra stranden av sjön Raslången i nordöstra Skåne. Bland fynden märkes ett större stamfragment. Den mikroskopiska undersökningen, som verkställdes på Naturhistoriska Riksmuseets paleobotaniska avdelning, visade särskilt vad den nämnda stocken beträffar en utomordentligt väl bevarad anatomisk struktur, som tillät en bestämning av veden till den mellantertiära *Taxodioxylon sequoianum* GOTHAN (identisk med veden av det i Kalifornien ännu kvarlevande jätteträdet *Sequoia sempervirens* ENDL.), en i Centraleuropas brunkol mycket vanlig vedtyp. Detta talar starkt för att Raslångsfynden äro av tertiär ålder, vilket ytterligare bestyrkes därav, att de enda bestämbara kretaceiska vedresterna från Sverige, de som finnas i Holmasandstenen vid Ivösjön och på Listerlandet, äro av en helt annan typ och tillhöra en annan konifergrupp. Övriga vedstycken från Raslången, liksom äldre lösa vedfynd från Skåne visa däremot alla, i den mån bevaringstillståndet tillåter, en liknande struktur som den stora stammen från Raslången, äro alltså av tertiär typ. De torde därför ej härstamma från Holmasandstenen utan från tertiära lager, som möjligen anstå eller anstått på botten av de djupa sjöarna i närheten. Att de ej transporterats några längre sträckor visar bl. a. deras koncentrerade förekomst inom ett par begränsade områden. Strax V om Raslången gjordes sålunda fem fynd helt nära varandra, och NV om Simrishamn finnas inom ett par mils avstånd minst sex fyndorter. Den ostvästliga transporten kan ha skett genom den äldre baltiska isströmmen.

Med anledning av föredraget yttrade sig hrr HALLE, TROEDSSON, BACKLUND, DAHLSTEDT, J. EKLUND, GEIJER, HOLMQUIST och föredraganden.

Geolognytt.

Kungl. Vetenskapsakademien har från Hierta-Retzius stipendiefond tilldelat Docenten E. LJUNGNER, Uppsala, 500 kr. för bearbetning av kartografiskt material från expeditionen till Patagonien 1932—1934, Lektor O. ISBERG, Luleå, 500 kr. för en paleontologisk-stratigrafisk undersökning av musslor från Gotland och Fil. Kand. G. SANDBERG, Uppsala, 1,000 kr. för studier av tjälskjutning och jordflytning såsom växtbiologiska faktorer. Bland reseunderstöd till yngre naturforskare för undersökningar rörande landets naturförhållanden erhöll Amanuensen C. E. NORDENSKJÖLD 250 kr. för morfologiska studier inom övergångsområdet mellan Kalmarslätten och Tjustbygden.

Från fonden Lars Hiertas minne ha understöd tilldelats Fil. Dr A. LUNDEGREN för utredning av krithavets nordgräns i Sydsverige m. m. och Docenten G. TROEDSSON för undersökning av rät-liasformationen i Skåne.

Ur Längmanska kulturfonden ha anslag utdelats bl. a. till: Professorskan E. HULT DE GEER, Stockholm, för att åvägabringa en fast årtalsdatering genom sektioner av stubbar i våra torvmossar; Docent E. LJUNGNER, Uppsala, för bekostande av fotografiska kopior av negativ från de patagoniska Anderna; Docent S. PALMQVIST, Lund, för geokemiska undersökningar över vissa lerors bildningsmekanism; Prof. E. STENSIÖ, Stockholm, för framställande av original till illustrationer för en monografi över hjärnkapselns byggnad hos vissa devoniska crossopterygier; Fil. Lic. G. SÄVE SÖDERBERGH, Stockholm, för tryckning av ett arbete rörande triassiska stegocephaler från Spetsbergen.

Från Kungl. och Huitfeldtska stipendieinrättningen har Fil. Mag. A. LUNDELL, Lund, erhållit 600 kr. för fortsatta geologiska undersökningar i Dalsland.

Geografiska sällskapet i Leipzig har till hedersledamot utsett Prof. H. W:SON AHLMANN, Stockholm, och till korresponderande ledamot Docenten N. HÖRNER, Uppsala.

Den 4 april försvarade i Uppsala Fil. Lic. T. KROKSTRÖM en avhandling med titeln: The Hällefors Dolerite Dike and some Problems of Basaltic Rocks (Bull. Geol. Inst. Ups., Vol. XXVI). Opponenter voro Prof. H. BACKLUND och Docenten H. VON ECKERMANN.

Bergsingenjör OLOF EKLUND, Stockholm, har av danska Grönlandsstyrelsen anförtrotts ledningen av den planerade marmorbrytningen i Västgrönland.

Sveriges geologiska undersöknings fältarbeten under sommaren 1936.

Statsgeologen S. JOHANSSON utför agrikulturgeologiska och hydrogeologiska specialundersökningar samt slutför revisionen för beskrivning över jordarterna till kartbladet Lidköping.

Statsgeologen R. Sandegren avslutar jordartskartläggningen på kartbladet Horndal samt rekognoscerar på kartbladet Vårvik.

Extrageologer: J. A. Bergquist, O. Claesson, E. Claesson och T. Krokström.

Statsgeologen N. Sundius utför en berggrundsgeologisk undersökning av Ornöområdet i Stockholms län.

Statsgeologen N. H. Magnusson leder och övervakar berggrundskartläggningarna på kartbladen Hedemora och Vårvik samt utför malmgeologiska undersökningar inom den mellansvenska bergslagen, huvudsakligen för det sammanfattande verket rörande dennas järnmalmsfyndigheter.

Statsgeologen G. Lundqvist påbörjar och bedriver den geologiska kartläggningen av kartbladet Hedemora samt leder i anslutning därtill instruktionskursen i geologisk kartering för nyantagna extrageologer.

Extrageologer: H. Thomasson, Hj. Bjurulf, S. J. Bjurulf och F. E. Wickman.

Statsgeologen B. Asklund utför praktiskt geologiska undersökningar inom västra och södra Sveriges granitindustriområden samt Jämtlands län.

Extrageologer: R. Norin och V. Larsson.

Statsgeologen E. Granlund slutför revisionen för beskrivningen till den praktiskt-geologiska kartan över jordarterna nedanför odlingsgränsen i Västerbottens län.

Extrageolog: C. Larsson.

Statsgeologen A. Högbom utför malmgeologiska undersökningar i Västerbottens fjälltrakter samt avslutar revision för beskrivning av berggrundskartan över Västerbottens län.

Extrageolog: T. Du Rietz.

Geologen G. Ekström fortsätter den geologiska undersökningen av jordarterna på kartbladet Lund, utför i anslutning därtill agrogeologiska undersökningar inom angränsande delar i Skåne samt utför hydrogeologiska undersökningar inom valda specialområden.

Extrageologer: F. Rengmark och E. Mohrén.

Geologen P. Thorslund utför praktiskt-geologiska undersökningar och stratigrafiska utredningar inom de kalkstensförande områdena i Jämtlands län.

Fil. Dr S. Hjelmqvist reviderar berggrunden på kartbladet Smedjebacken samt utför (under samarbete med statsgeologen Magnusson) malmgeologiska utredningar.

Geologen J. Eklund utför malmgeologiska utredningar inom de nedre delarna av Västerbottens län.

Gruvingenjör K. A. Barkenberg leder de gruvtekniska undersökningsarbetena inom Västerbottens län.

Fil Lic. S. Gavelin utför malmgeologiska specialundersökningar i malmfyndigheterna inom Skelleftefältet i Västerbottens län.

Fil. Dr G. Beskow utför väggeologiska fältutredningar inom utvalda delar av landet.

Prof. P. Geijer utför utredningar för arbetet över den mellansvenska bergslagens järnmalmsfyndigheter.

Fil. Dr O. Kulling utför en undersökning över bergarterna och stratigrafien inom sparagmitavdelningen i Västerbottens län.

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Medlemmar av Föreningen erhålla genom skattmästaren de äldre banden av Förhan lingarna och Generalregistret till hälften av det ovan upptagna bokhandelspriset. Å lö häften lämnas ej prisnedsättning. (Styrelsens beslut d. $^{27}/_{10}$ 1922.)

Geologiska Föreningens sekreterare, Statsgeolog R. Sandegren, träffas i Föreninge angelägenheter å Sveriges Geologiska Undersökning, tisd. och fred. kl. 11 f. m.—12 Tel. 319818 och 319819. Efter kl. 6 e. m. Tel. Djursholm 272. Efter överenskommel per telefon kan sekreteraren även träffas å Stockholms Högskolas Geologiska Institut.

Föreningens **ordinarie möten** äga rum första helgfria torsdag i månaderna febr ari, mars, april, maj, oktober, november och december. Dagen för januarimötet bestämmes decembersammankomsten. Anslag om föredragningslistan finnas minst 3 dagar före sa manträdet uppsatta på anslagstavlorna å följande offentliga institutioner: Stockholms Högsko Tekniska Högskolan, Bergshögskolan, Jernkontoret, Sv. Geol. Undersökning, Statens Meteorologis Hydrografiska Anstalt, Statens Skogsförsöksanstalt, Statens Järnvägars Geotekniska avd., Ups Univ:s Geolog., Geogr., Paleont. och Växtbiol. inst. samt Lunds Univ:s Geol. inst.

Personlig kallelse till sammanträdena utfärdas på därom gjord framställning t sekreteraren.

Häftena utdelas sammanträdesdagarna i januari, mars, maj och n vember.

Uppsatser, avsedda att införas i Förhandlingarna, insändas till Föreningens sekretera Sveriges Geologiska Undersökning, Stockholm 50. Åtföljande tavlor och figurer böra va fullt färdiga till reproduktion, då de jämte uppsatsen sändas.

I Förhandlingarna må uppsatser — förutom på skandinaviskt språk — införas på e gelska, franska eller tyska; dock vare författare skyldig att i de fall då Styrelsen anser dant önskvärt bifoga en resumé på skandinaviskt språk.

Därest korrektionskostnaderna för införd uppsats uppgå till mera än 16 kronor tryckark, vare författare skyldig att erlägga det överskjutande beloppet, såvida det uppg till minst 10 kr. pr uppsats.

Författare erhåller gratis 75 separat av införda uppsatser.

Referat honoreras sålunda (Fören. beslut $^{7}/_{12}$ 1911):

1:sta sidan eller del därav . . . . efter 20 öre pr tryckrad.
2:dra › › › › . . . . › 15 › › ›
3:dje › › › › . . . . › 10 › › ›
Följande sidor honoreras icke.

Anmälan om **föredrag** göres i god tid hos sekreteraren.

Ledamöternas årsavgifter, vilka enligt § 7 av Föreningens stadgar skola vara inbetal senast den 1 mars, insändas till Föreningens skattmästare, Dr K. E. SAHLSTRÖM, Sverig Geologiska Undersökning, Stockholm 50, till vilken Föreningens ledamöter även to insända uppgifter om ändringar av adresser och titlar. Årsavgifter, som ej äro inbetal den 1 mars, är skattmästaren skyldig att ofördröjligen inkräva.

Årsavgiften utgör kr. 15: —, avgift såsom ständig ledamot kr. 200: —. Ledam som under en följd av minst 20 år erlagt årlig ledamotsavgift, kan bliva ständig ledam mot en avgift av kr. 100: —.